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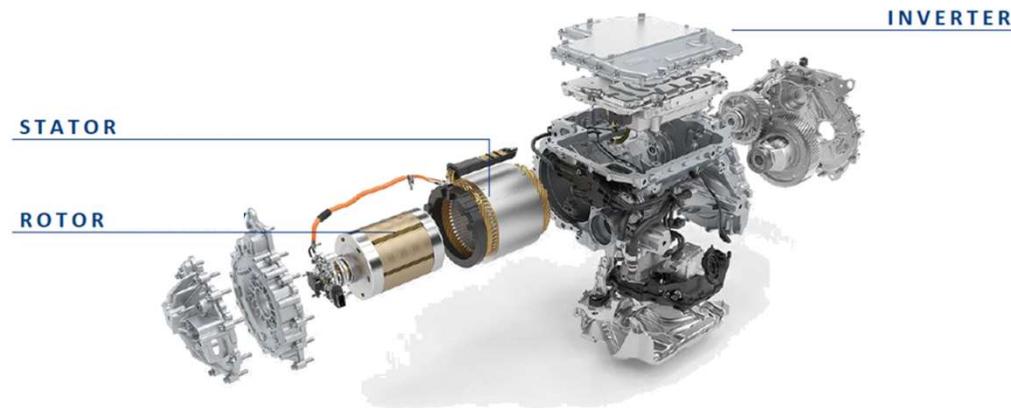


EDM

Electric Drive Module

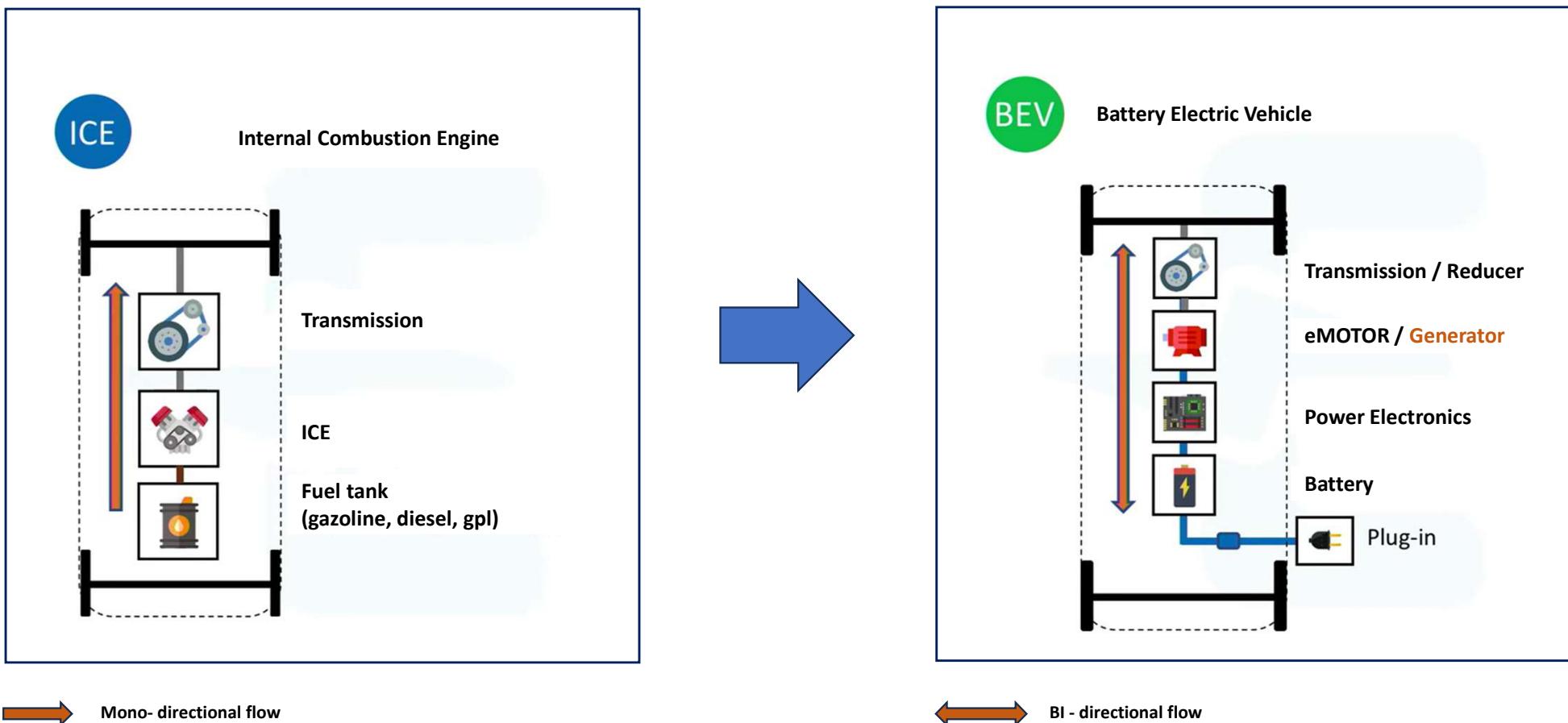
Outline

1. Why an EDM / What is an EDM
2. EDM main components
3. General Layout of an EDM production process
4. Main operation in EDM, eMOTOR, PIM assembly
5. Some main trends in EDM «Product»
6. Some main trends in EDM «Process»
7. Q&A

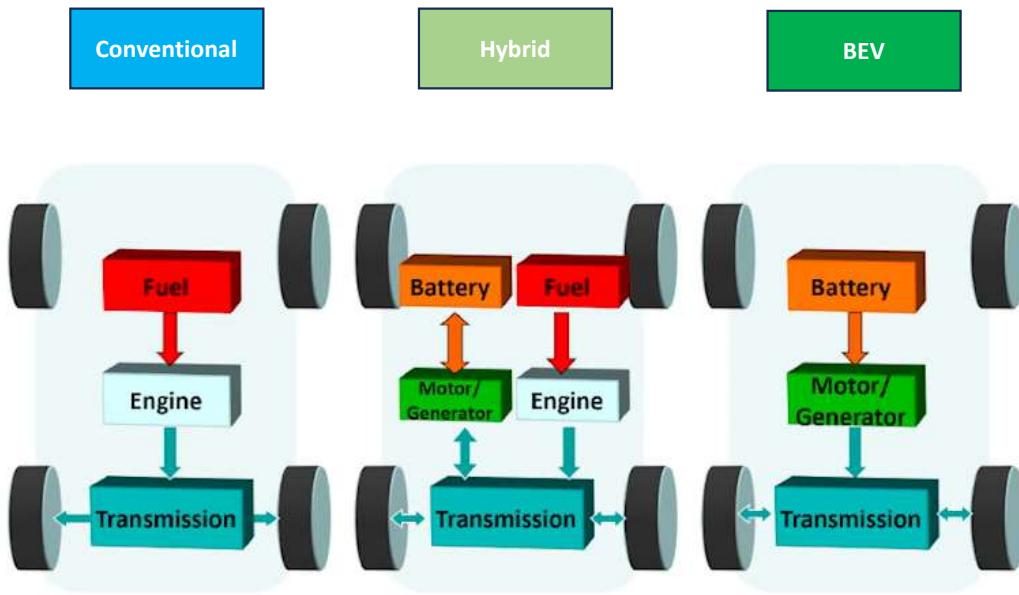


Why an EDM

In the new era of **eMOBILITY**, automobiles systems are passing from **ICE based** model to **EV based** model. Such a big paradigm change has been assured by a **New Powertrain architecture**.

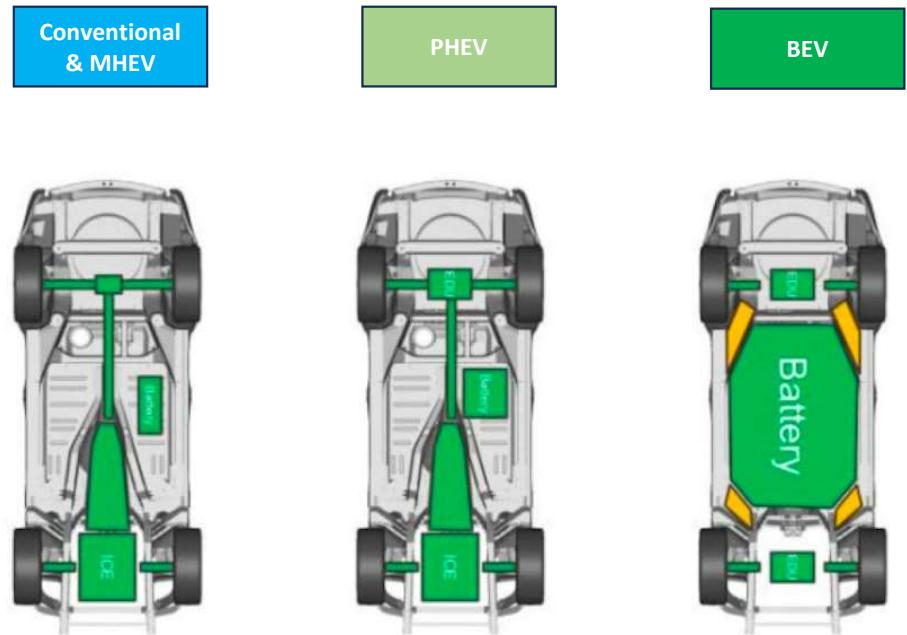


Why an EDM, Vehicle & PWT «evolution»



Different PWT evolution.

Hybrid system capable to store electric energy in a battery usable to move vehicle powering the EDM

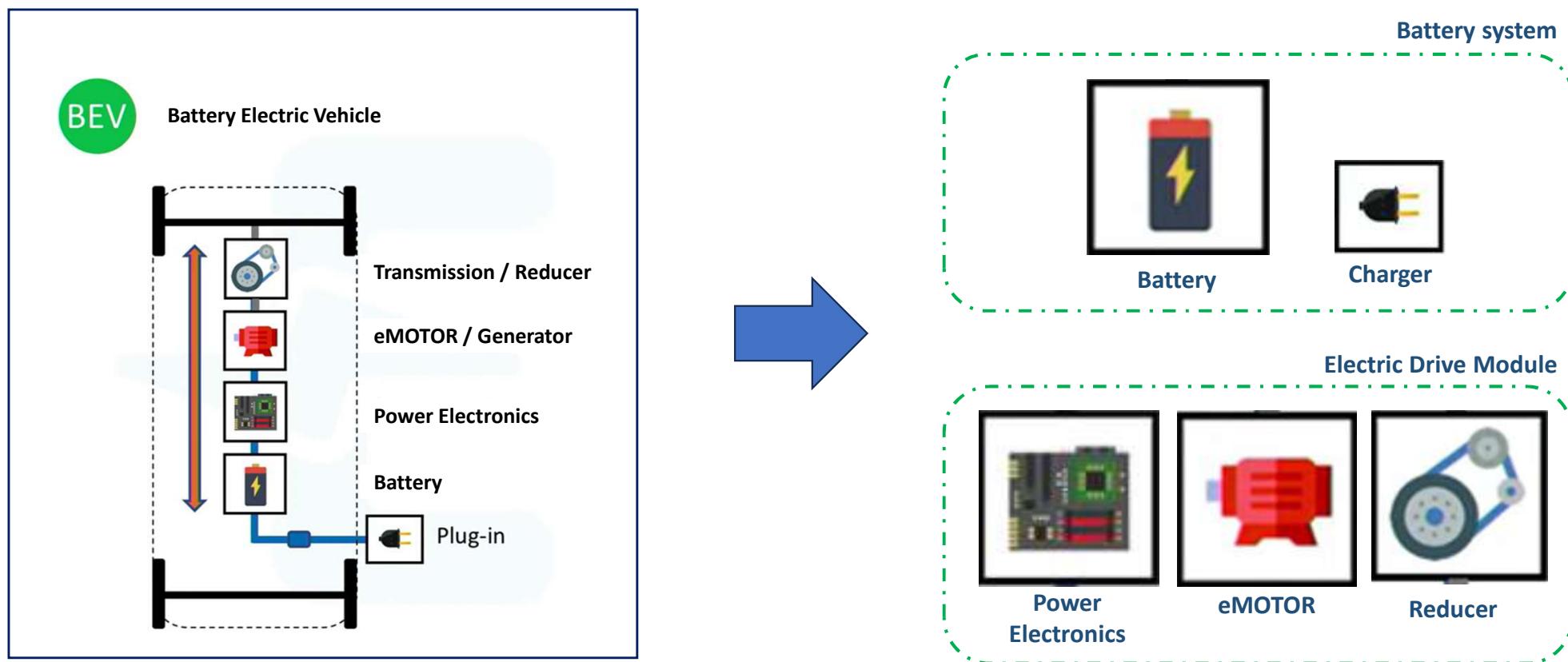


Different Battery evolution & dimensions

What is an EDM

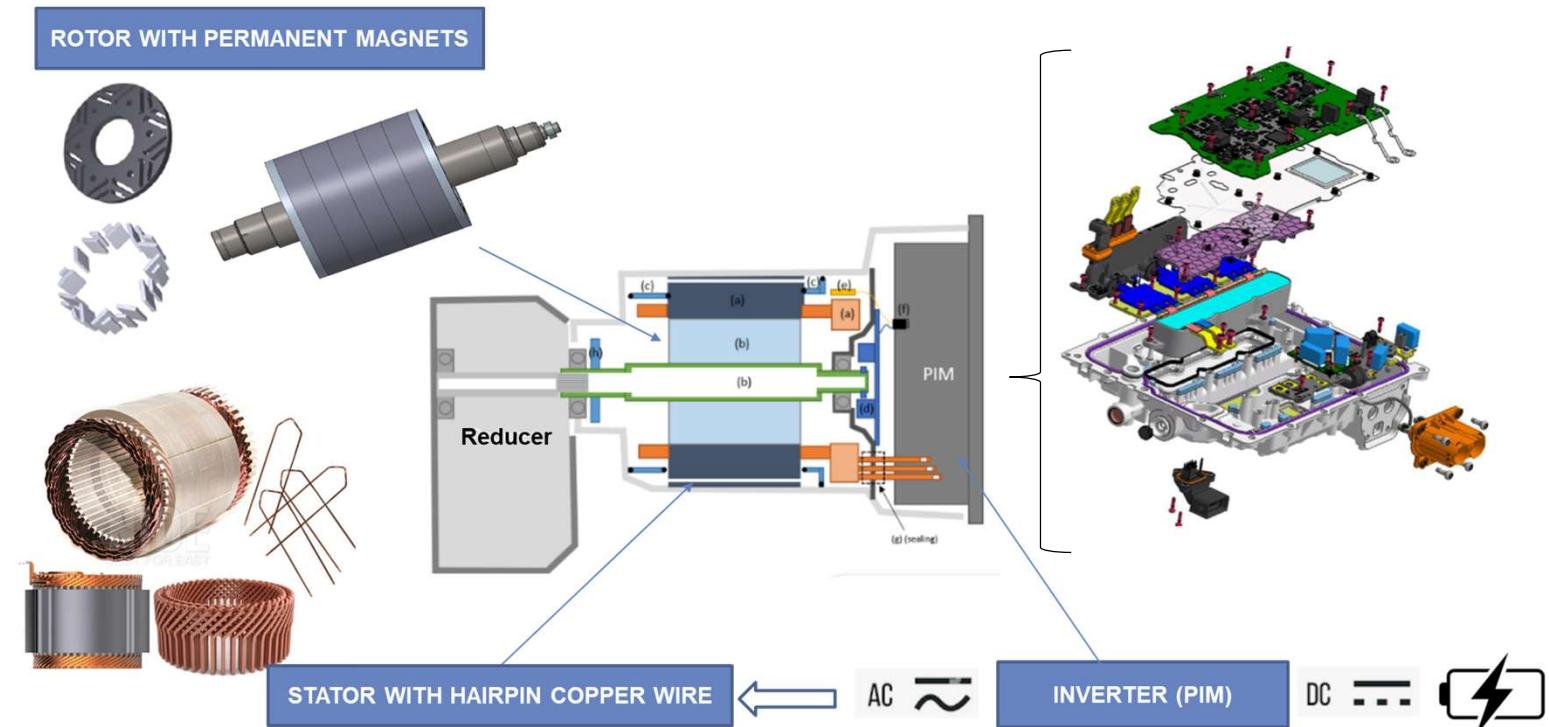
In a Full Electric Vehicle or **Battery Electric Vehicle (BEV)** the motion to the wheels is ensured by the Electric Drive Motor (**EDM**), replacement of traditional Powertrain.

The EDM is “fueled” by the Battery system (**Battery Pack**), evolution of the standard tank.



What is an EDM, EDM interaction mode with Active Parts & Inverter

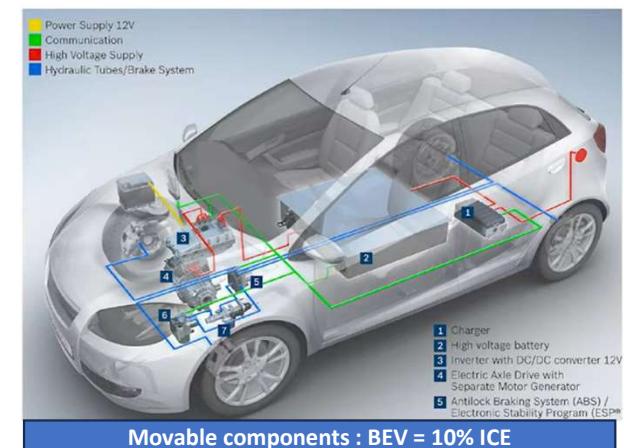
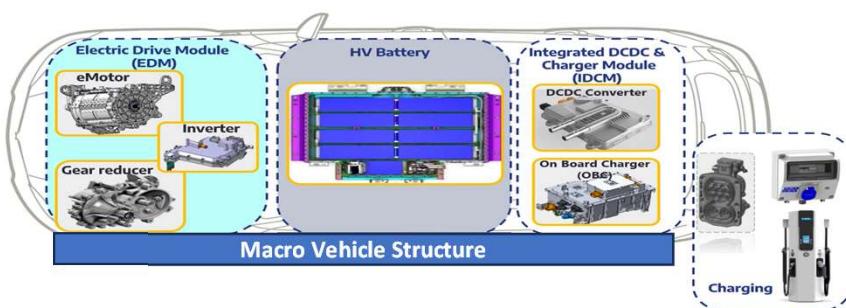
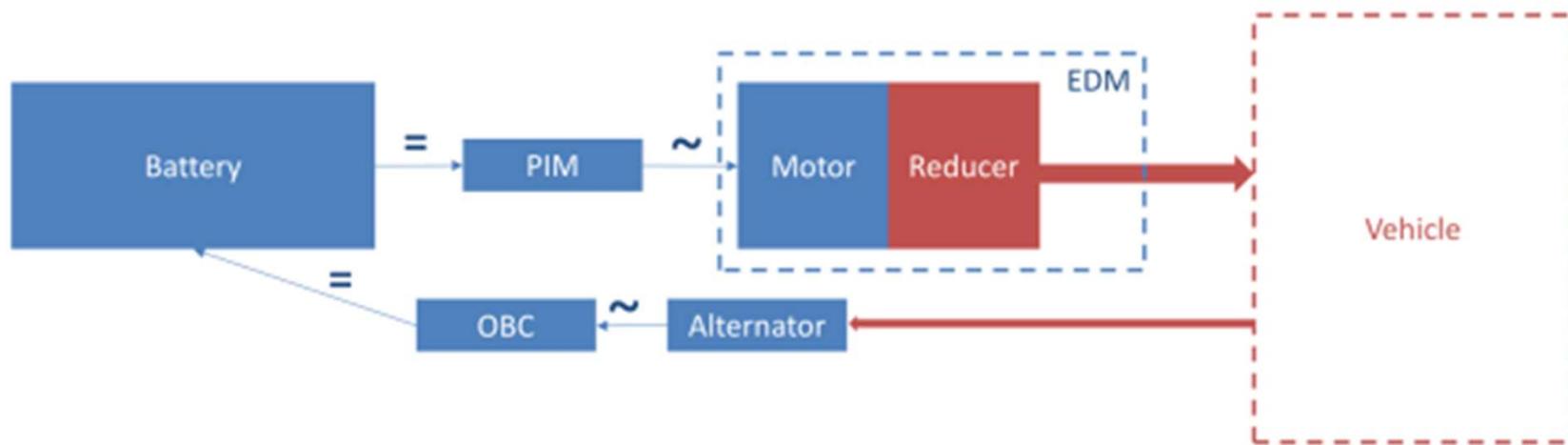
In a Full Electric Vehicle or **Battery Electric Vehicle (BEV)** the battery supply electrical energy in DC. PIM Inverter transform (**invert**) from DC to AC the electrical supply to the eMOTOR (**Stator**). Via the **Electromagnetic** field interaction, the **rotor** is put in rotation. Via the **reducer** (shafts, gears, differential) the motion is transferred to the **differential**. The differential transfer the motion to the **wheels**.



What is an EDM

In a Full Electric Vehicle or **Battery Electric Vehicle (BEV)** the motion to the wheels is ensured by the Electric Drive Motor (**EDM**), replacement of traditional Powertrain.

The EDM is “fueled” by the Battery system (**Battery Pack**), evolution of the standard tank.

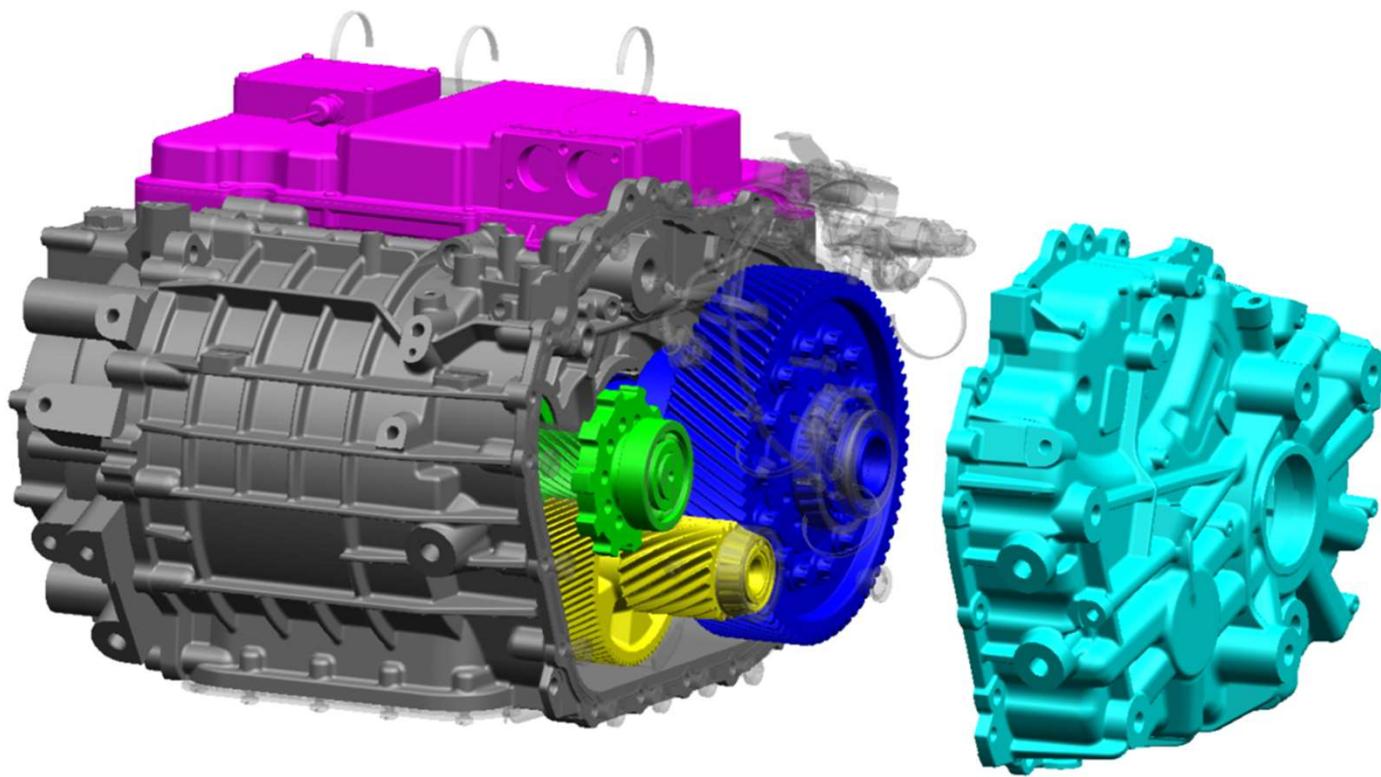


EDM Main components

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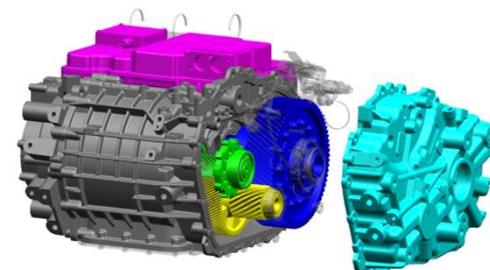
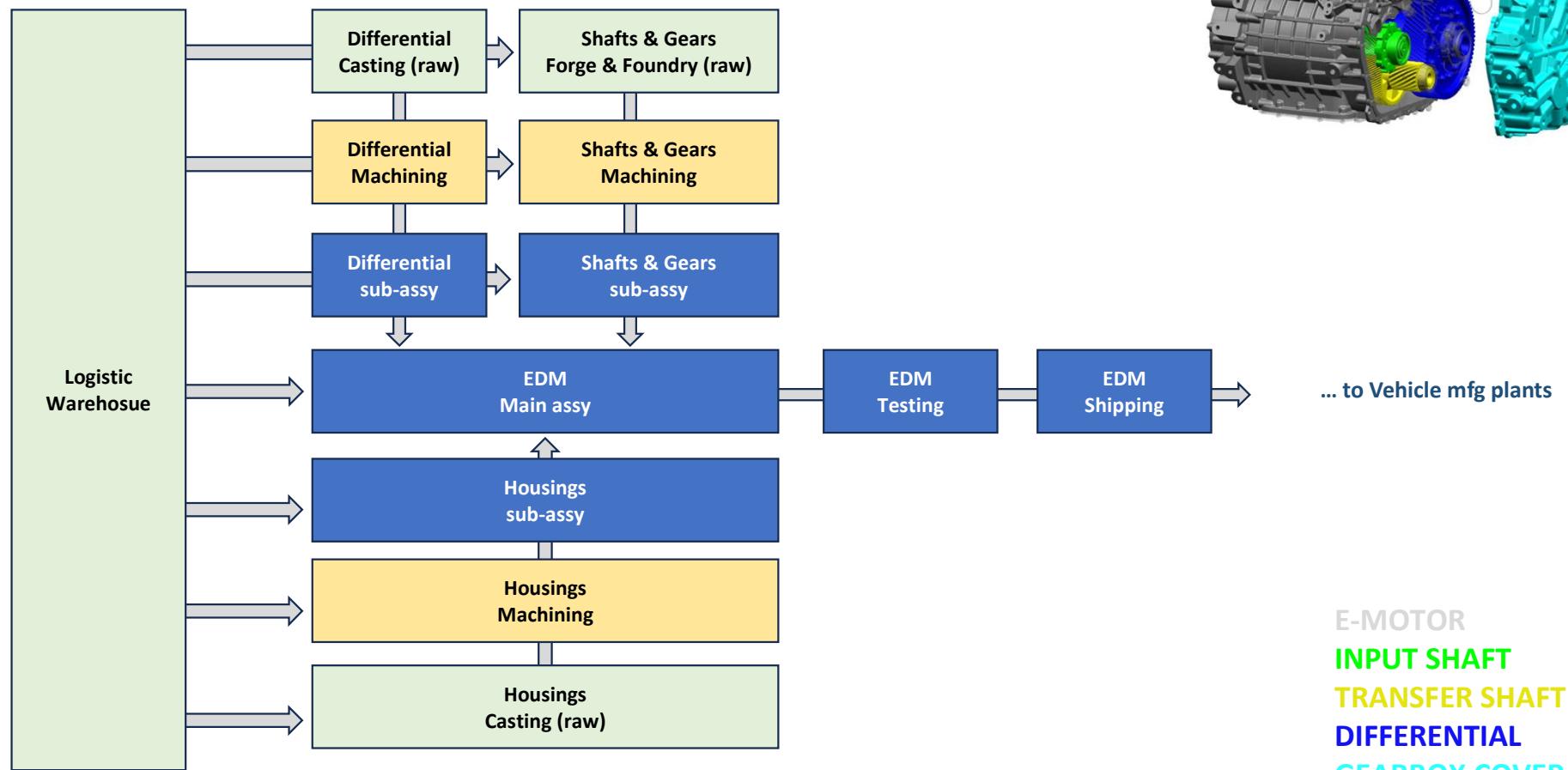


E-MOTOR
INPUT SHAFT
TRANSFER SHAFT
DIFFERENTIAL
GEARBOX COVER
PIM INVERTER

General Layout of an EDM production process «carry over» of a Transmission one



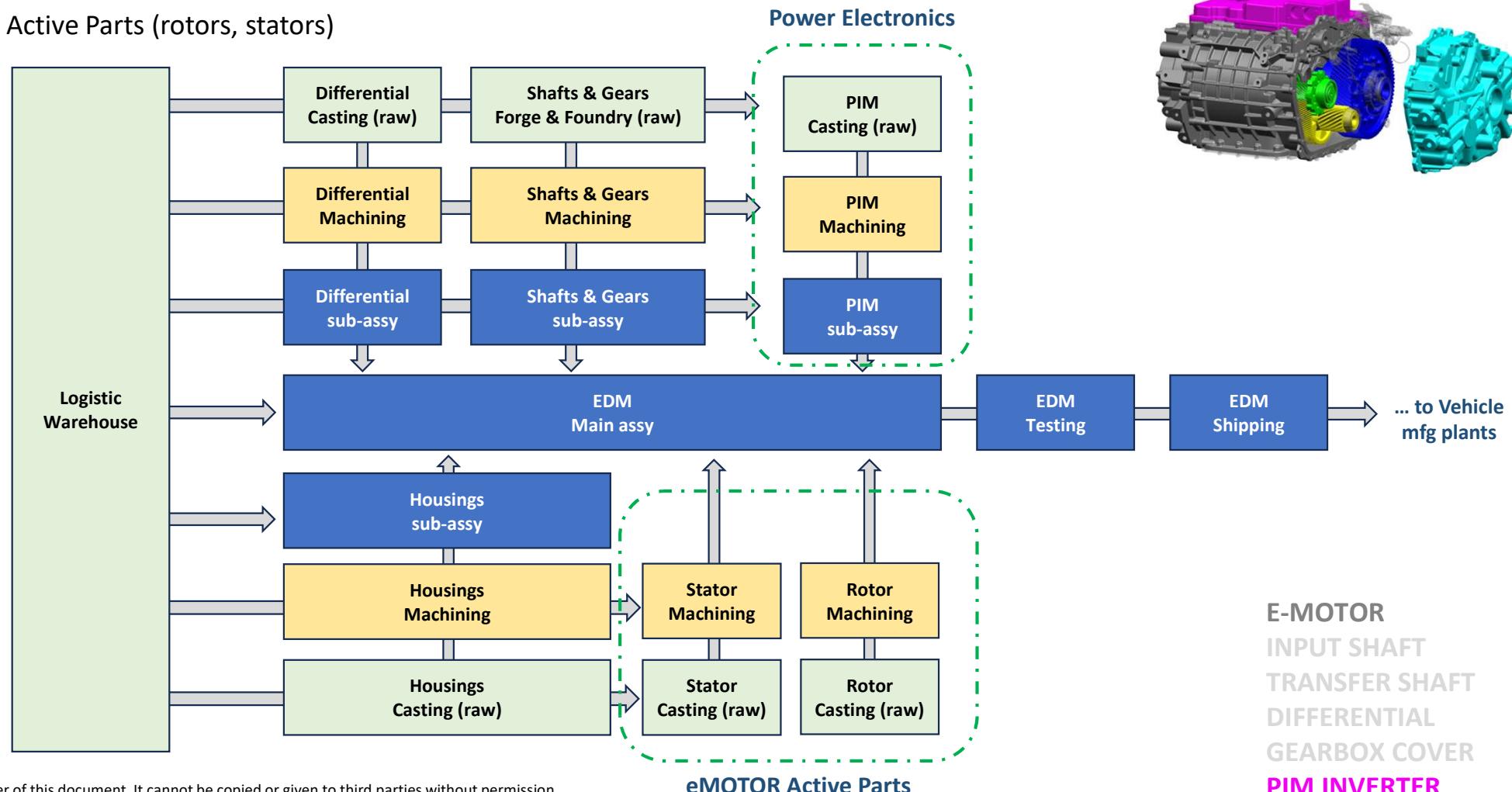
Quite similarly to a classic manufacturing layout for a standard **Transmission** component, the **EDM layout** is deployed based on some key area/processes.



General Layout of an EDM production process with specific contents

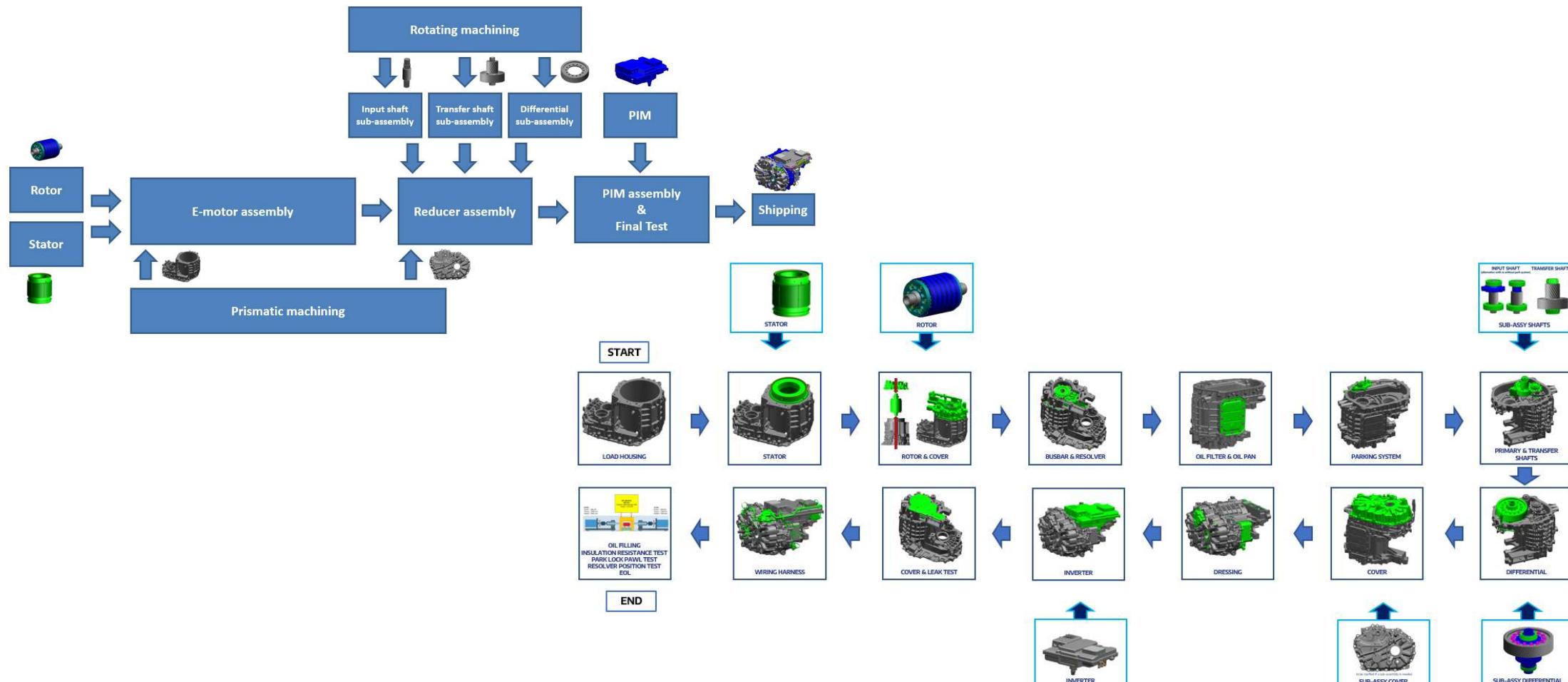
Specific EDM core components to be considered as additional contents :

- PIM Inverter
- eMOTOR / Active Parts (rotors, stators)

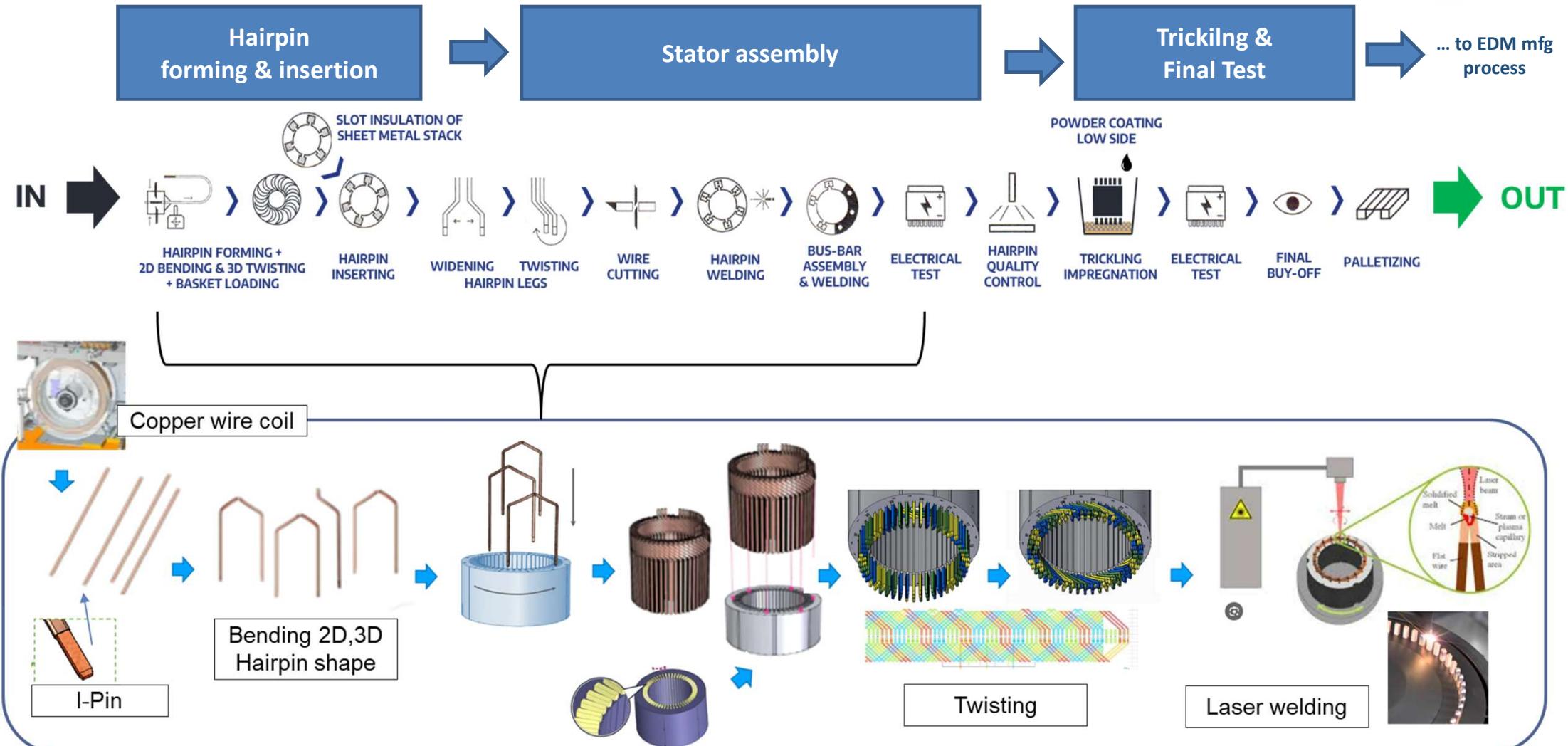


Main operation in EDM assembly

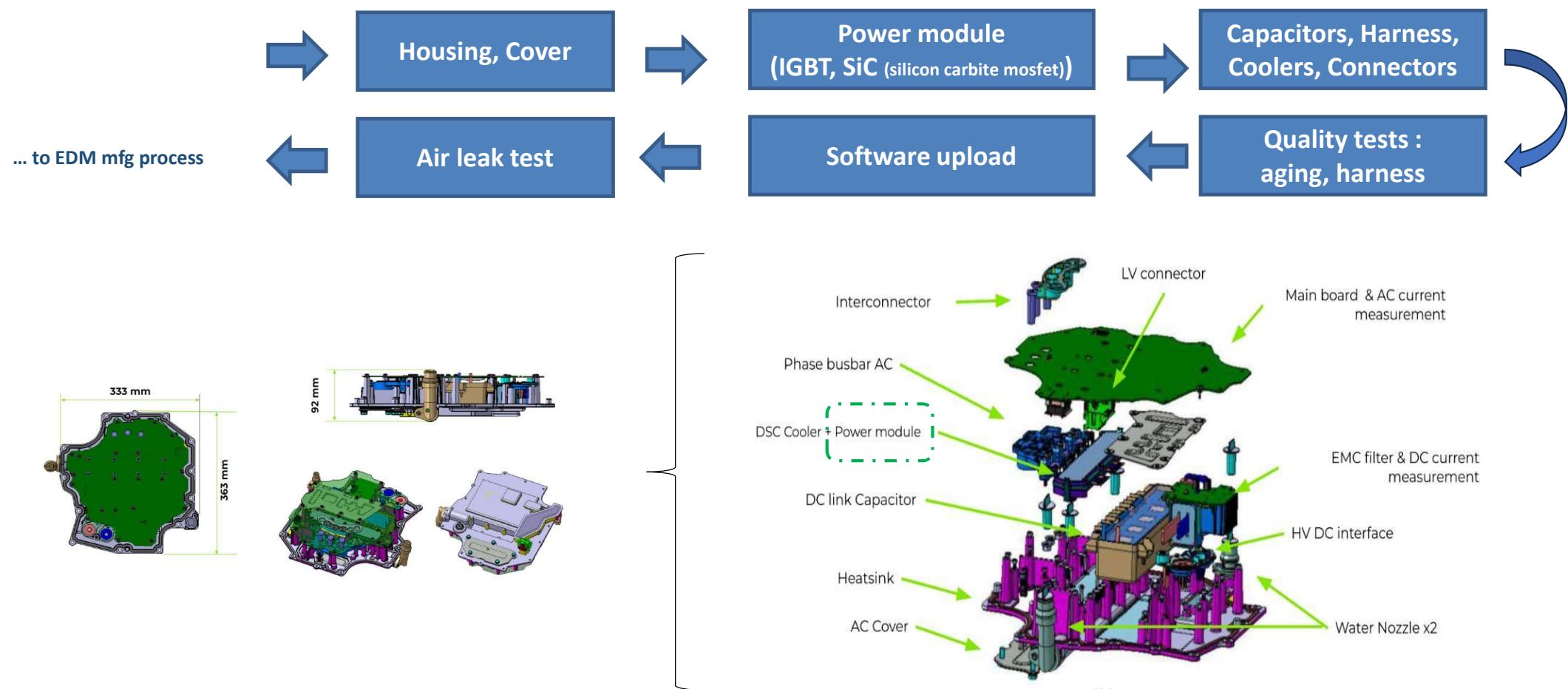
Main consideration : comparing with a classical PWT transmission the **EDM** cinematic archyture represent a much **simplified structure** : Input shaft + Output (Transfer) shaft + 1 single speed ratio coupled with a ring gear/differential.



Main operation in eMOTOR Active parts (e.g. Stators) assembly



Main operation in PIM assembly



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Trend in EDM « Product »

Main Trend 1

Define X in 1 Electrical architecture for future STLA platform

2 in 1 archetype :

- All main components managed «as single components»

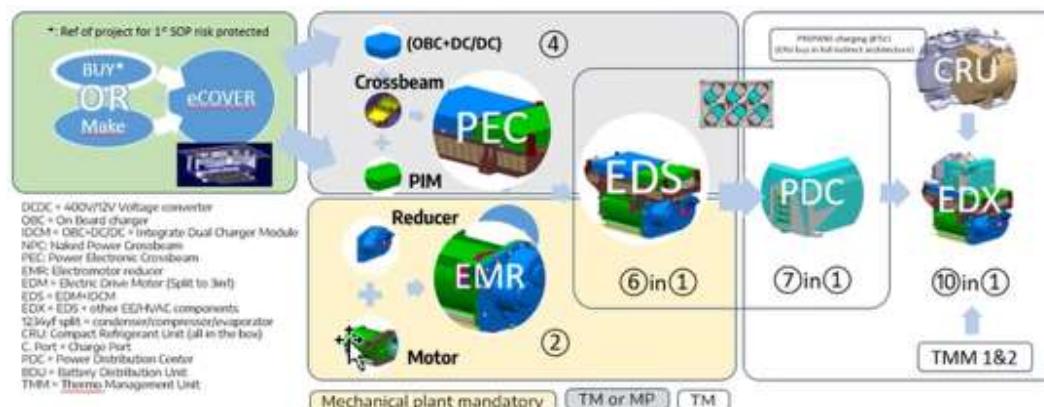
3 in 1 archetype :

- Reducer
- eMOTOR
- PIM Inverter



X in 1 archetype :

- Reducer
- eMOTOR
- PIM Inverter
- IDCM (On Board Charger)
- DC/DC converter
- CROSSBEAM
- PDC
- CRU (Compact Refrigerant Unit)
- EDX



Main Trend 2

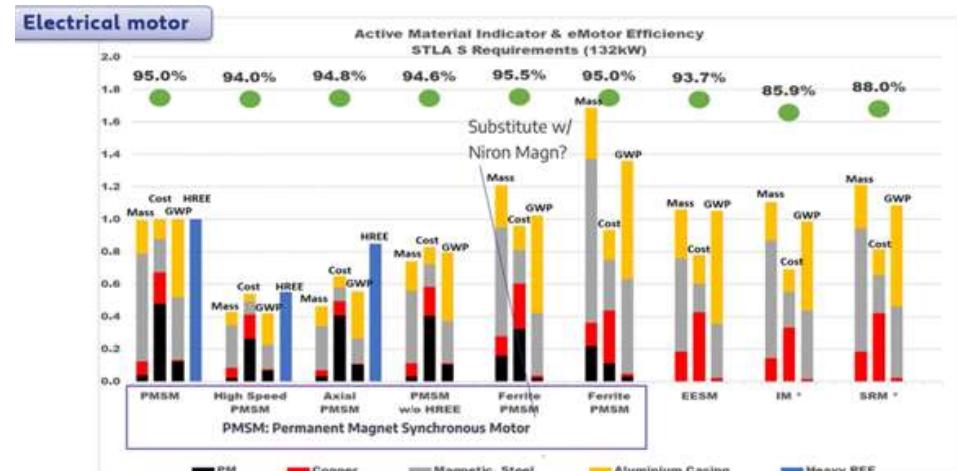
Propose REE (Rare Earth Elements) & HREE Free EDM with lowest GWP (Global Warming Potential) as alternative to PMSM (Permanent Magnet Synchronous Motor).

Alternative Tech solutions in terms of eMOTOR in consideration of different parameters :

- EESM : Eletrically Excited Synchronous Motor
- IM : Induction Motos
- SRM : Switched Reluctance Motor

Main drivers :

- Cost reduction opportunities
- Material Scarcity management
- Management of Dipendency from China supply (Raw Material, Semi-Finished components, Finished components)



GWP: Global Warming Potential

REE: Rare Earth Elements

HREE: Heavy REE

PMSM: Permanent Magnet Synchronous Motor

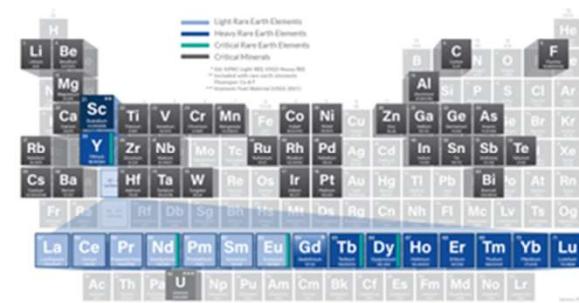
EESM: Electrically Excited Synchronous Motor

IM: Induction Motor

SRM: Switched Reluctance Motor

Trend in EDM « Product », Rare Earth focus

Rare Earth



- 17 metallic elements, classified into 2 groups: Light (LREE) and Heavy (HREE)
- Not remarkably rare, but desired REEs occur in low concentrations, inefficient and environmentally impactful processing
- 4 elements of interest: Neodymium (Nd), Praseodymium (Pr), Dysprosium (Dy) and Terbium (Tb)

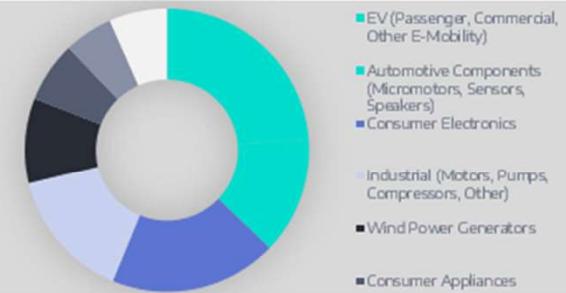
LREE	HREE
59 140.9766 Pr Praseodymium Lanthanide	60 144.24 Nd Neodymium Lanthanide
65 158.92535 Tb Terbium Lanthanide	66 162.500 Dy Dysprosium Lanthanide

Why is RE Important?

1. Usage across Industries

- Nd, Pr, Dy, Tb account for >90% of RE market value
- Used in production of high-performance permanent magnets (largest RE segment)
- Crucial to several clean and high-tech industries: Mobility, Wind Energy, Robotics, Consumer Products

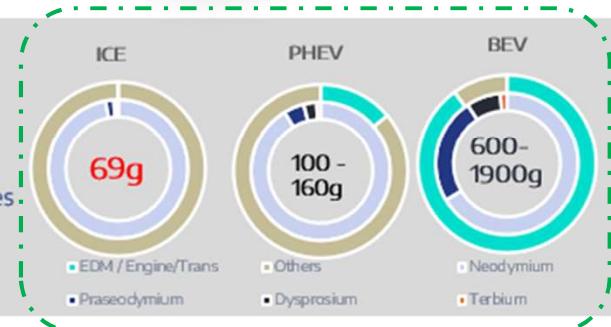
Source: Adamas



2. Vehicle Use

- Rare Earths are used in EVs to promote:
 - Energy-efficiency, lightweighting, thermal management, traction and range
- RE exposure in ICE vehicles is in Speakers, Power Steering, Sensors, Micromotors, Brakes
- Main application in EV is NdFeB (Permanent) Magnets in eMotors (**>90% of usage**)

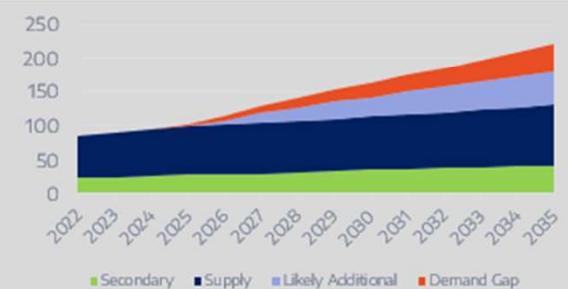
Source: IMDS



3. Growing Demand

- Consumption increased 7% annually since 2015 due to growth of EV and wind energy
- Largest segment: EV/Auto Components 34%
- Projected supply gap of approx. 90K NdPr, 1.8K Dy and 0.5K Tb tons by 2040 due to lack of primary and secondary sources

Source: Boston Consulting Group / Adamas



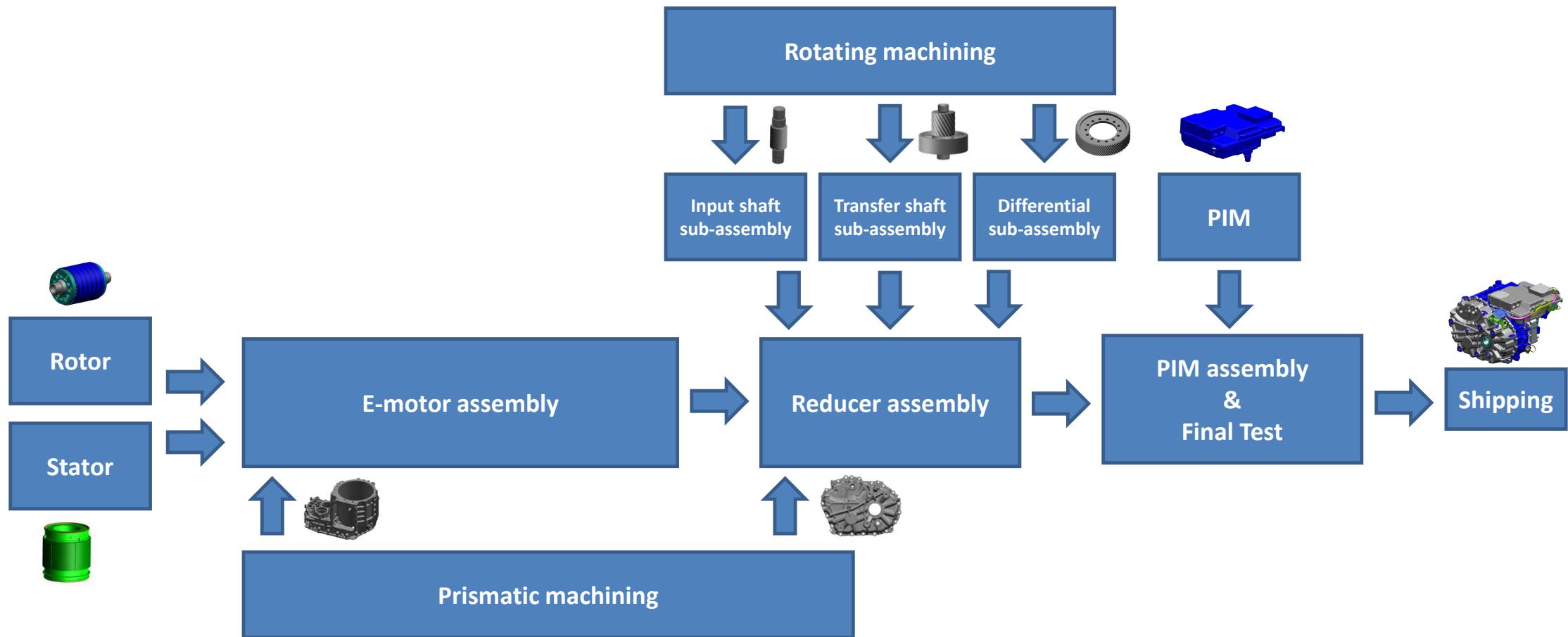
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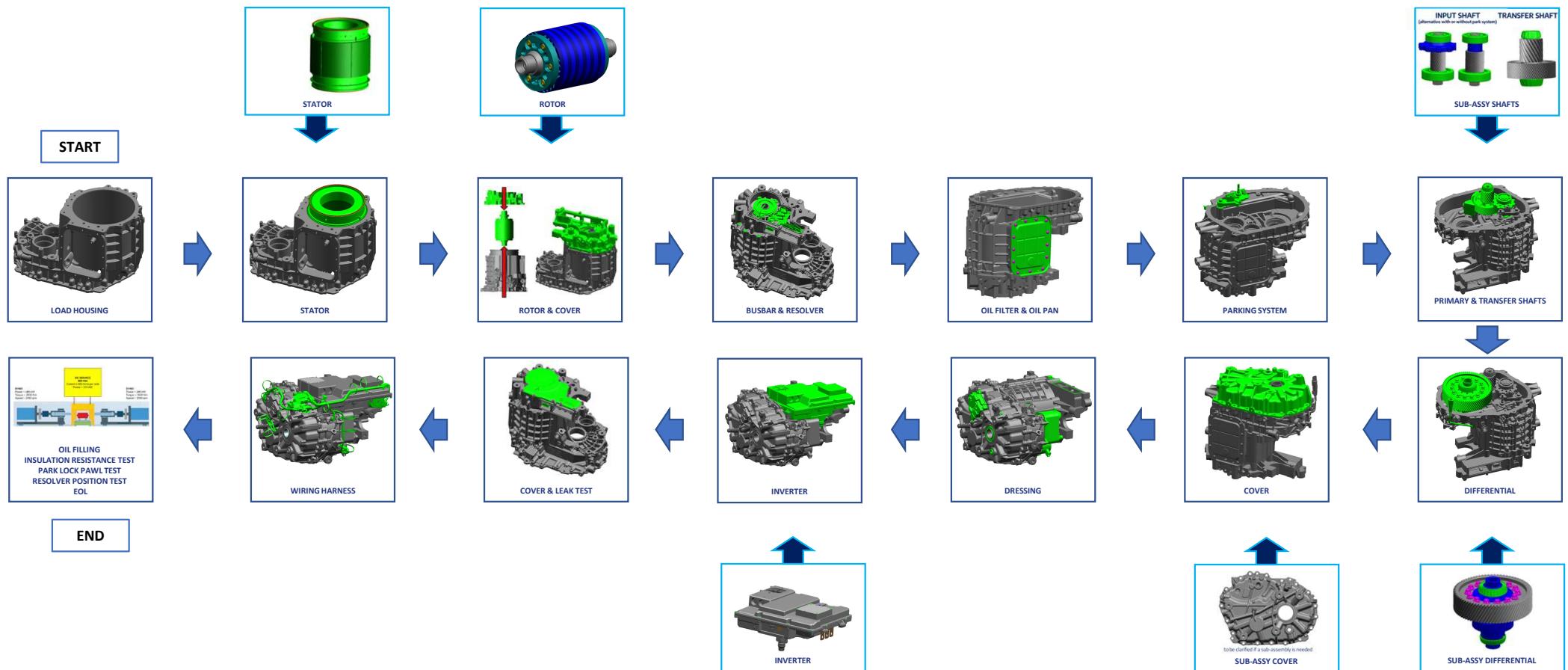
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Back Up

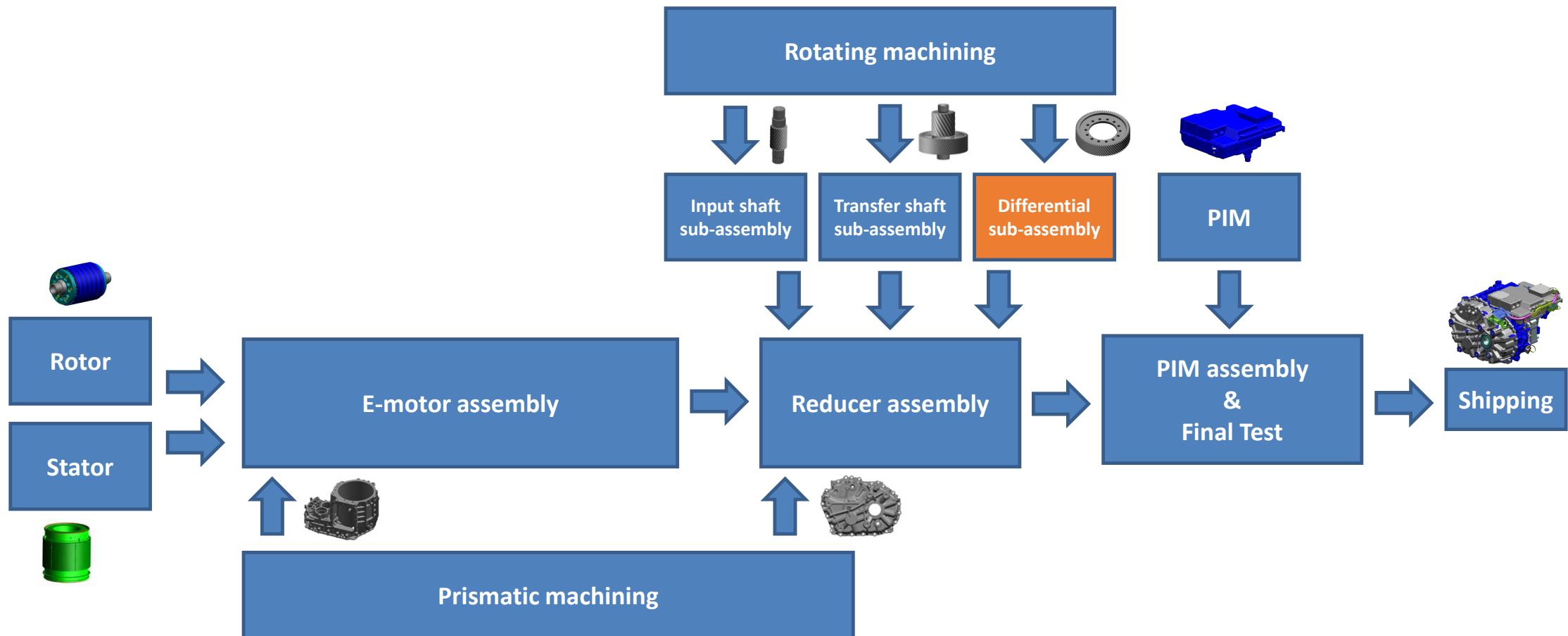
Process assembly flow



Process assembly flow



Process assembly flow



Sub-assembly differential

step 01



LOAD DIFFERENTIAL CASE BODY

step 02



RING GEAR PRESSING

step 03



RING GEAR BOLTS TIGHTENING

step 05



TAPERED ROLLER BEARING PRESSING

step 06



TAPERED ROLLER BEARING PRESSING

step 07



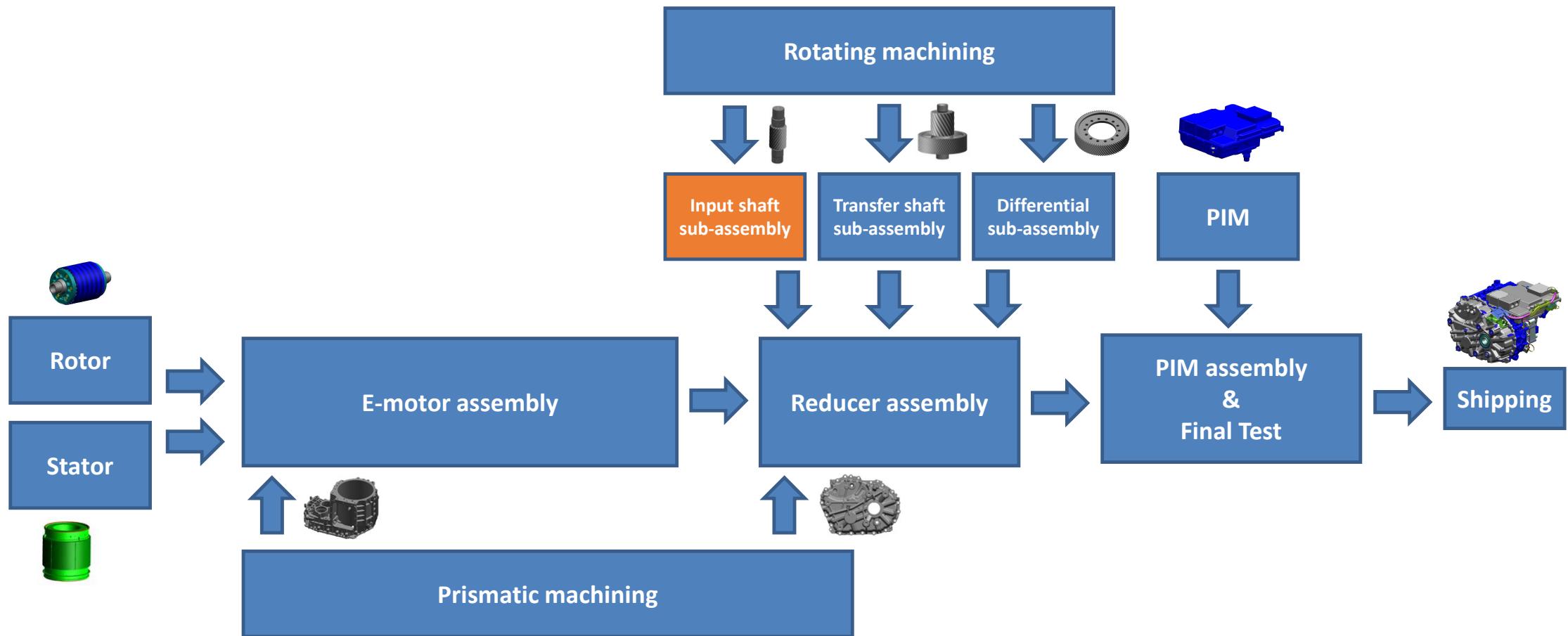
LASER MARKING

step 08



UNLOAD OF SUB-ASSY

Process assembly flow



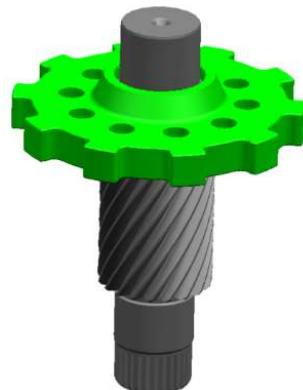
Sub-assembly input shaft

step 01



LOAD INPUT SHAFT

step 02



PARK LOCK ASSEMBLY

step 03



BALL BEARING PRESSING

step 04



BALL BEARING PRESSING

step 05

One Dimensional (1D Barcodes)	Two Dimensional (2D Barcodes)
UPC Code 030227411311	PDF417
Code 39 39123439	QR Code
Code 128 39123439	Data Matrix
Interleaved 2 of 5	Aztec Code

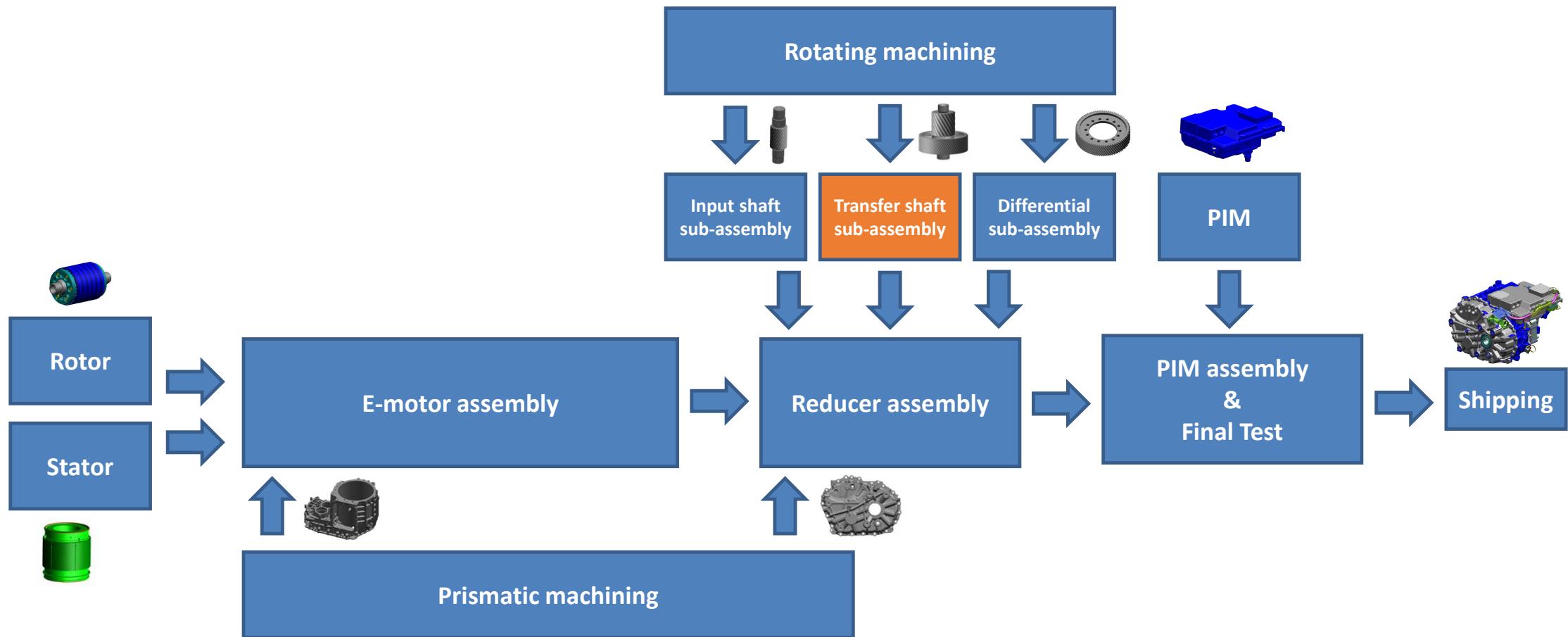
LASER MARKING

step 06



UNLOAD OF SUB-ASSY

Process assembly flow



Sub-assembly transfer shaft

step 01



LOAD TRANSFER SHAFT

step 02



TAPERED ROLLER BEARING PRESSING

step 03



TAPERED ROLLER BEARING PRESSING

step 04

One Dimensional (1D Barcodes)	Two Dimensional (2D Barcodes)
UPC Code 1234567891011	PDF417
Code 39 39123439	QR Code
Code 128 39123439	Data Matrix
Interleaved 2 of 5	Aztec Code

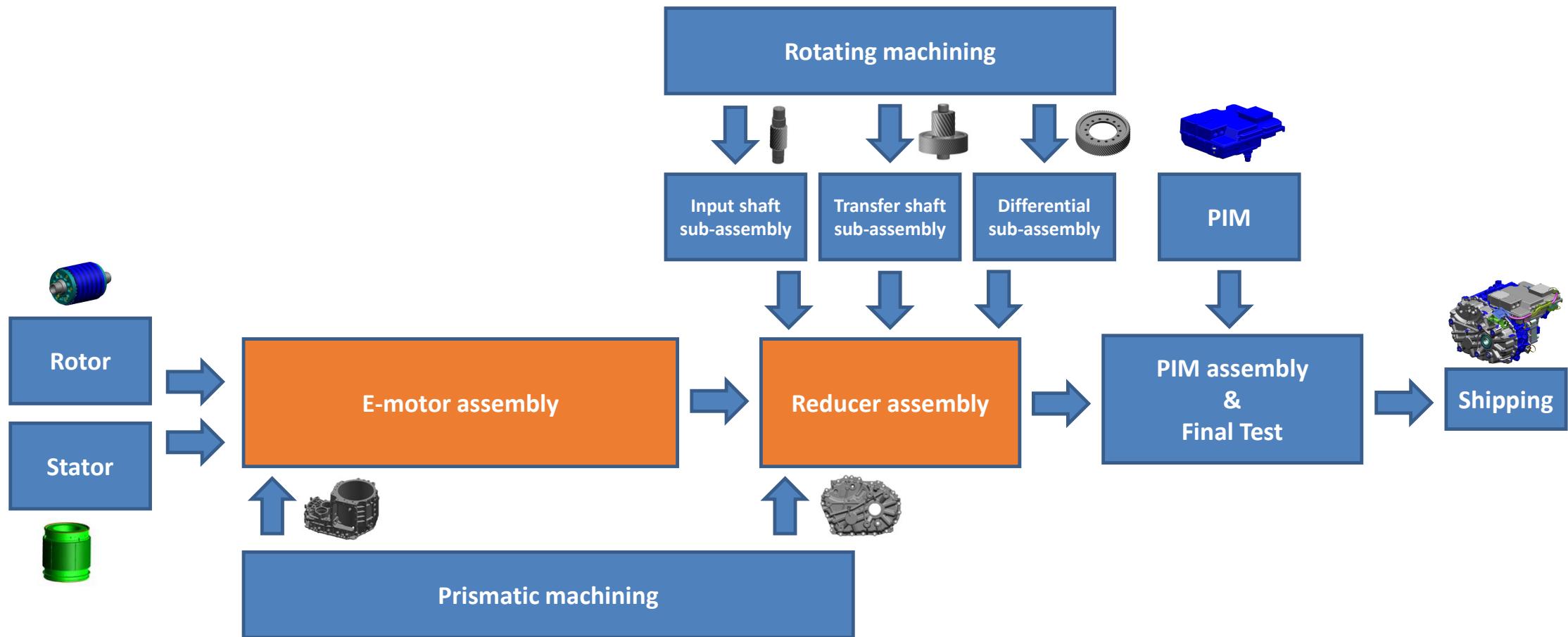
LASER MARKING

step 05



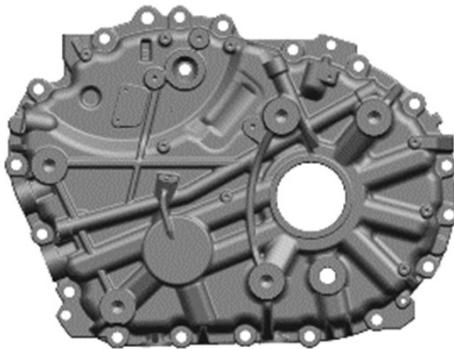
UNLOAD OF SUB-ASSY

Process assembly flow



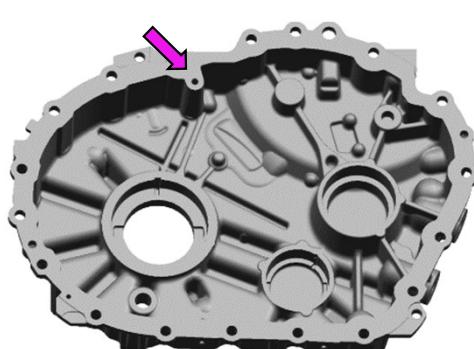
Sub-assembly gearbox cover (1/1)

step 01



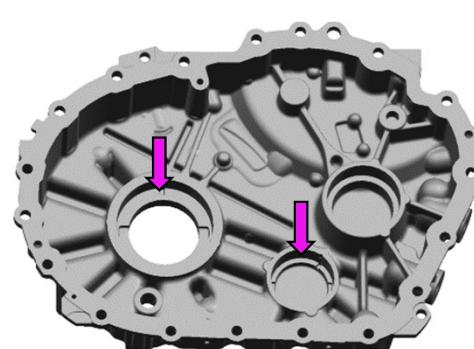
LOAD GEARBOX COVER

step 02



CUP PLUG PRESSING

step 03



MEASUREMENT FOR SHIMS

step 04

One Dimensional (1D Barcodes)	Two Dimensional (2D Barcodes)
123456789012	
UPC Code	PDF417
39123439	
Code 39	QR Code
39123439	
Code 128	Data Matrix
1234567890	
Interleaved 2 of 5	Aztec Code

LASER MARKING

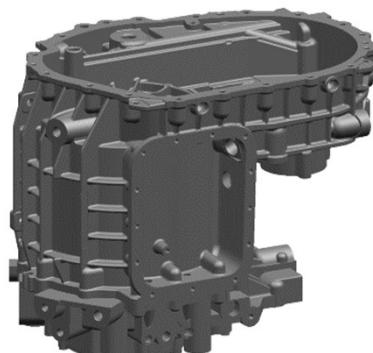
step 05



UNLOAD OF SUB-ASSY

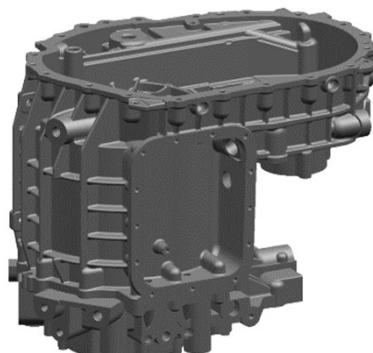
Main line (1/4)

step 01



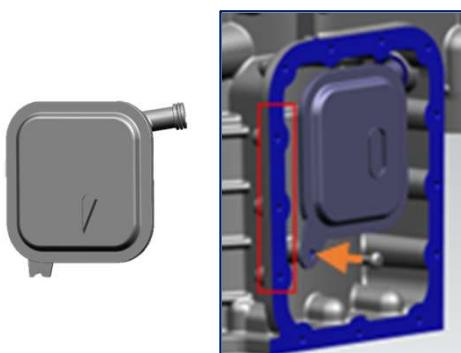
LOAD MOTOR HOUSING

step 02



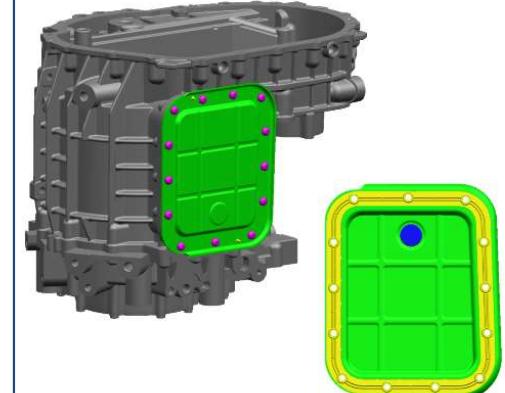
MOTOR HOUSING LABELLING

step 03



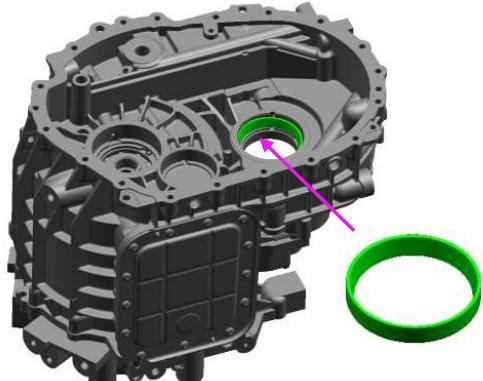
OIL FILTER ASSEMBLY

step 04



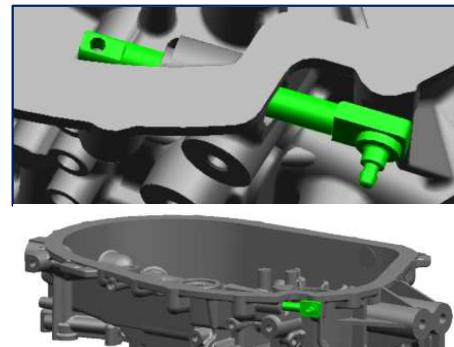
OIL PAN ASSEMBLY

step 05



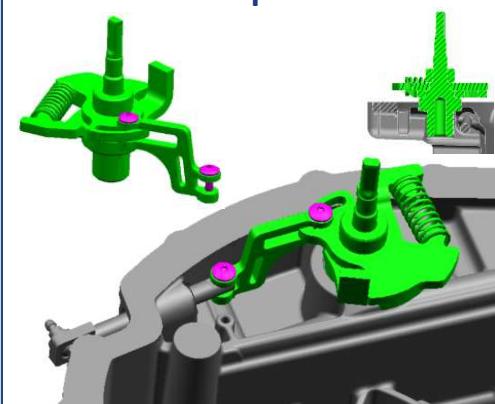
EXTERNAL BEARING PRESSING

step 06



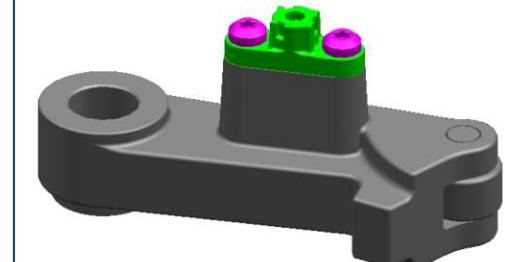
PULL ROD SHAFT ASSEMBLY

step 07



PARK LOCK CAM ASSEMBLY

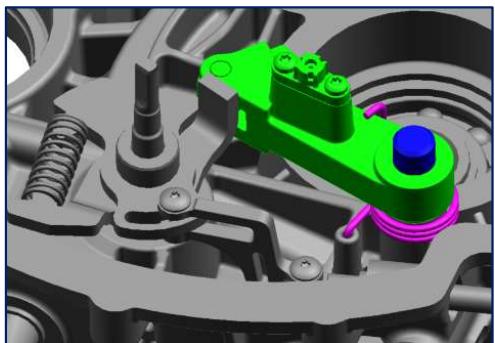
step 08



MAGNET CLIP ON PARK LOCK HOOK

Main line (2/4)

step 09



PARK LOCK HOOK ASSEMBLY

step 10



SUB-ASSY INPUT SHAFT

step 11



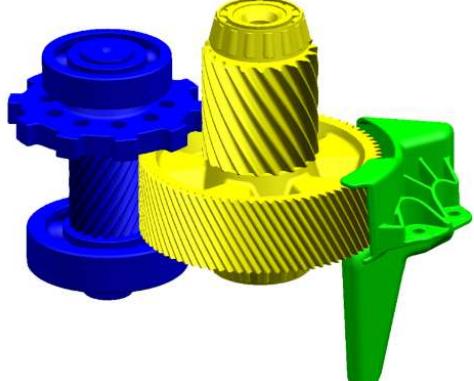
SUB-ASSY TRANSFER SHAFT

step 12



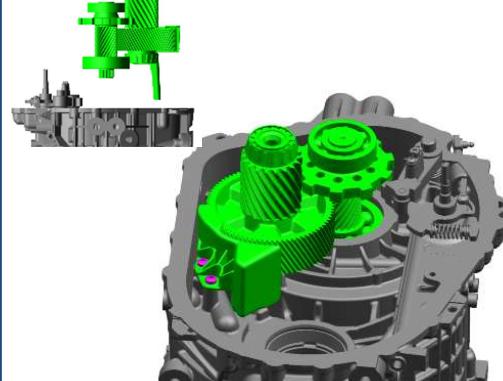
SUB-ASSY DIFFERENTIAL

step 13



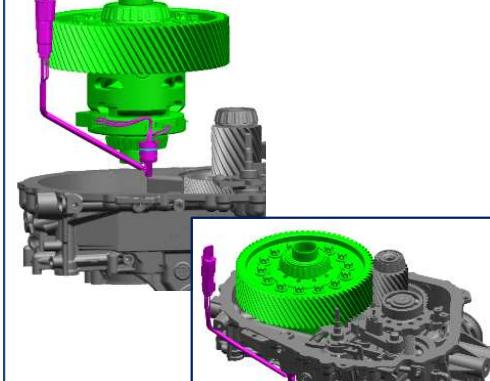
INPUT + TRANSFER + OIL BAFFLE PLATE

step 14



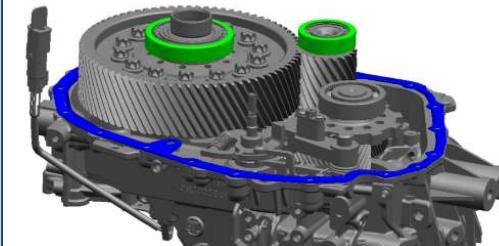
ASSEMBLY OF SHAFTS WITH OIL BAFFLE

step 15



DIFFERENTIAL GROUP ASSEMBLY

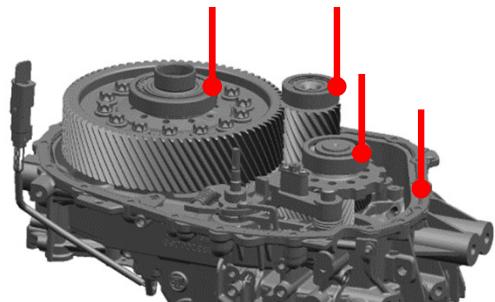
step 16



#2 OUTER BEARING RACE AND GASKET

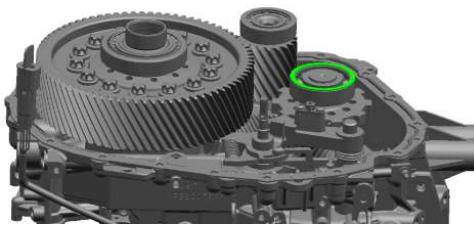
Main line (3/4)

step 17



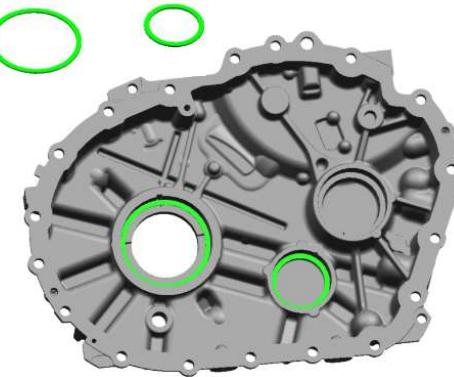
MEASUREMENT FOR SHIMS

step 18



#1 SHIM ON INPUT SHAFT (TBC)

step 19



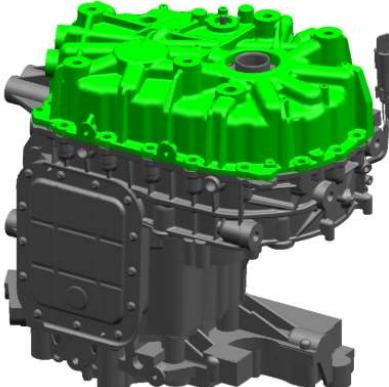
#2 SHIMS ON GEARBOX COVER

step 20



#2 OUTER BEARING RACE PRESSING

step 21



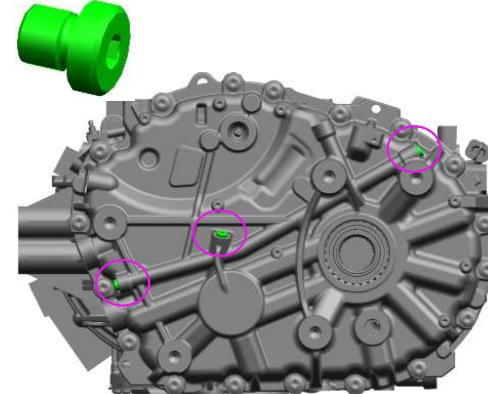
GEARBOX COVER ASSEMBLY

step 22



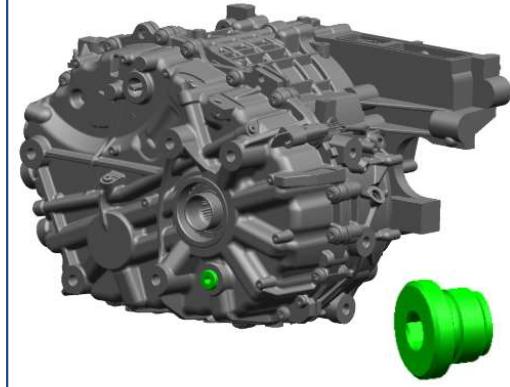
GEARBOX COVER SCREWING

step 23



SEAL PLUGS SCREWING

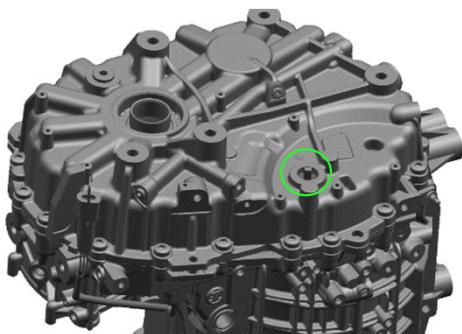
step 24



SEAL PLUG SCREWING

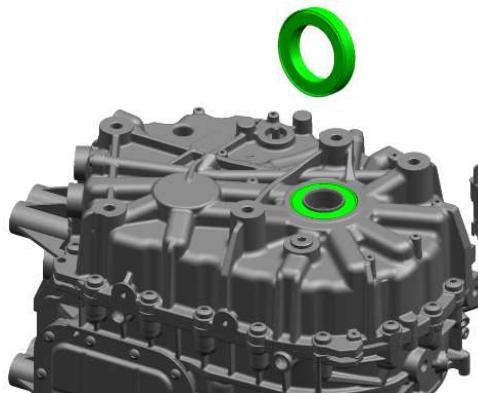
Main line (4/4)

step 25



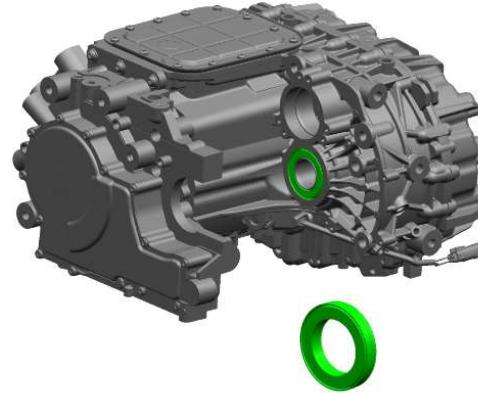
SEAL PARK LOCK PRESSING

step 26



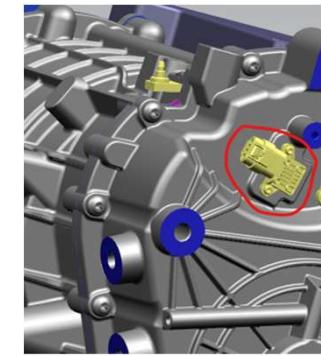
DIFFERENTIAL SEAL ON COVER

step 27



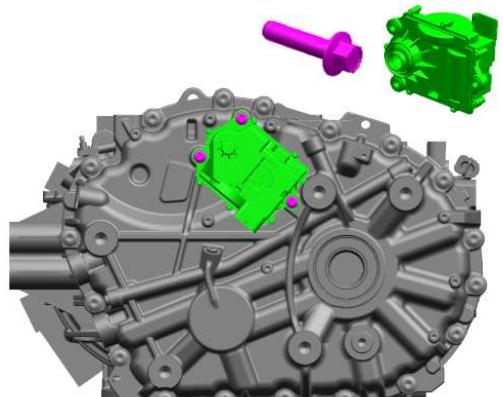
DIFFERENTIAL SEAL ON HOUSING

step 28



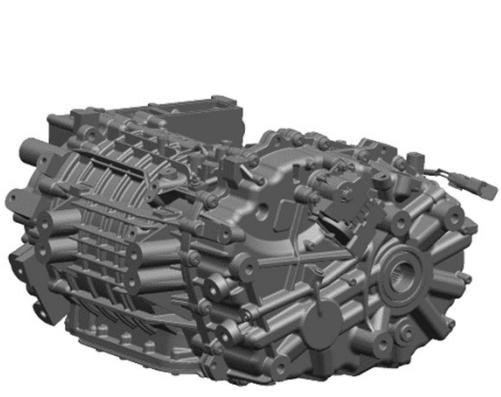
PARK LOCK SENSOR ASSEMBLY

step 29



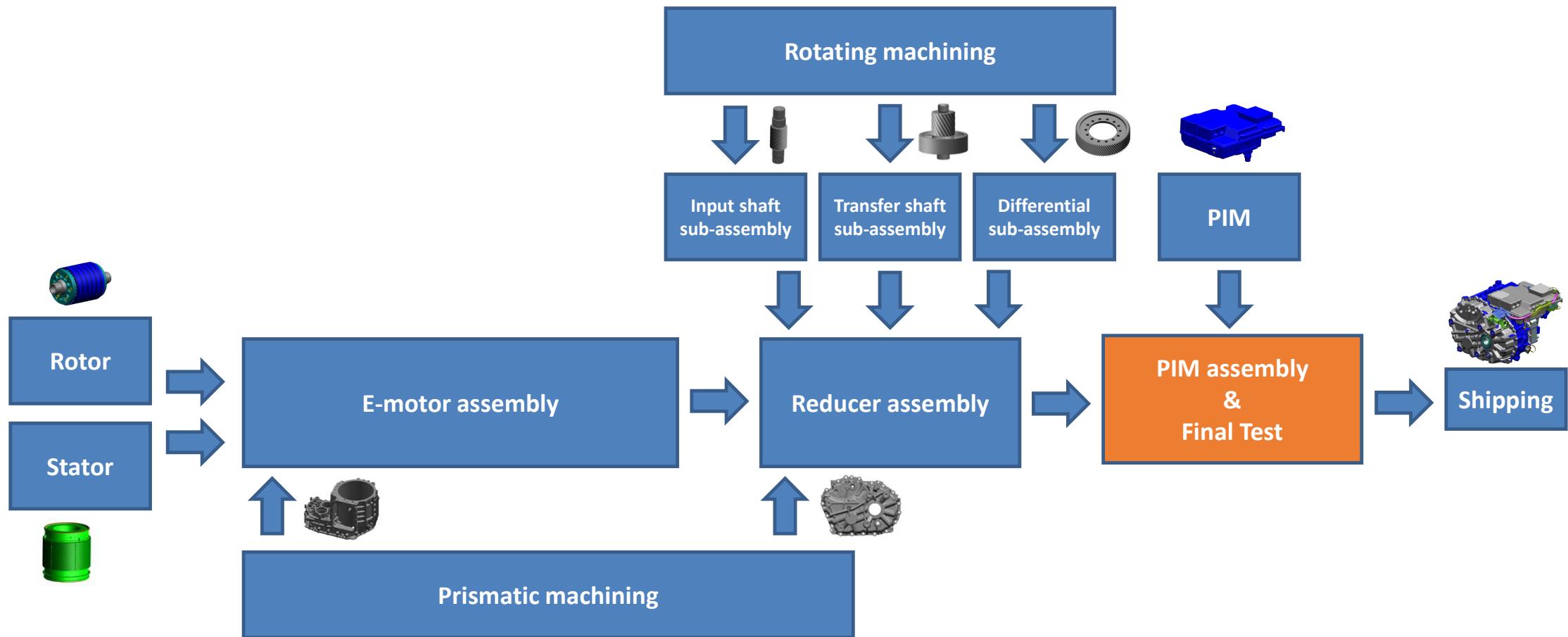
PARK LOCK ACTUATOR ASSEMBLY

step 30



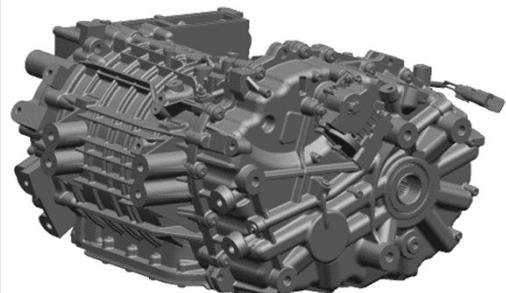
UNLOAD FROM ASSEMBLY PALLET

Process assembly flow



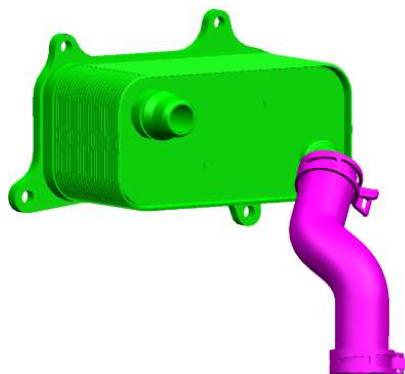
Test Loop (1/3)

step 01



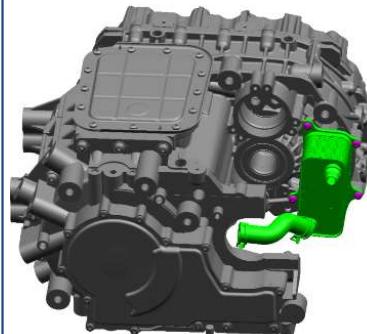
LOAD EDM TO PALLET TEST LOOP

step 02



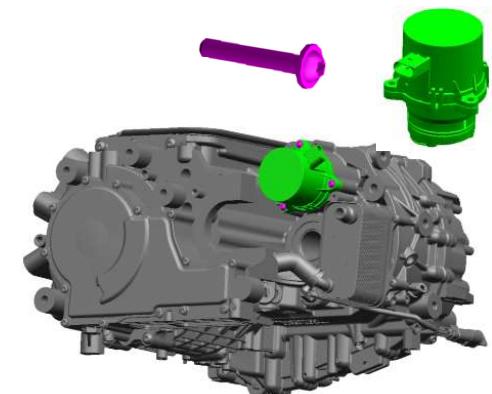
SUB-ASSY PIPE ON OIL COOLER

step 03



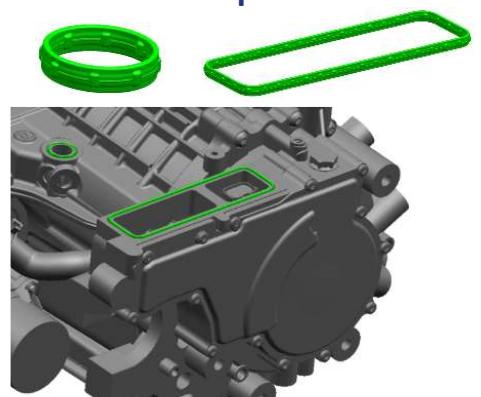
OIL COOLER ASSEMBLY

step 04



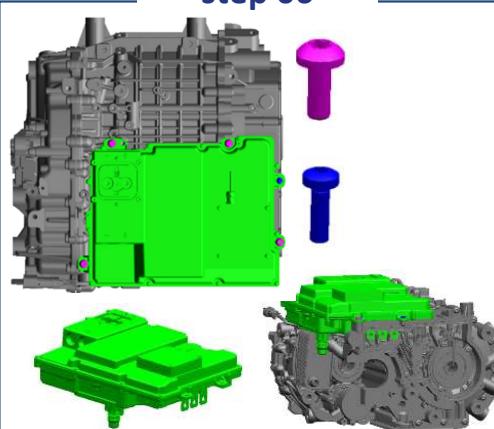
OIL PUMP ASSEMBLY

step 05



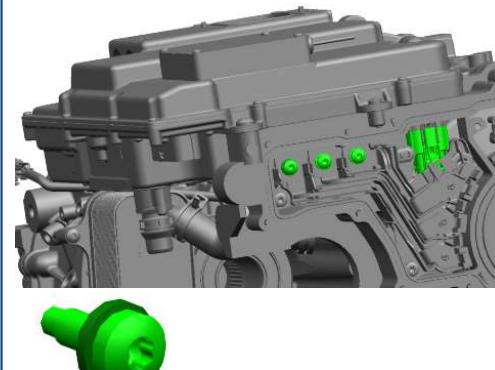
SEALS ASSEMBLY (#2 TYPE)

step 06



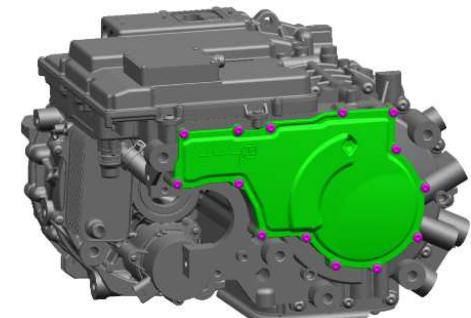
INVERTER ASSEMBLY

step 07



CONNECTION AND BUSBAR SCREWING

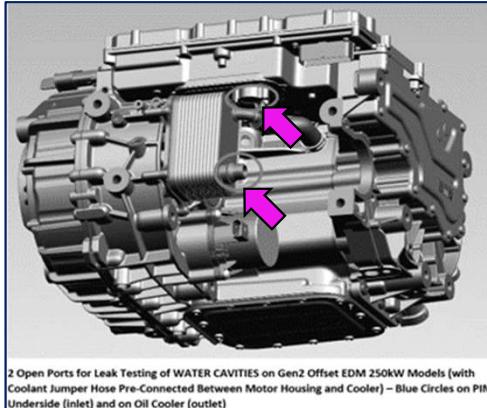
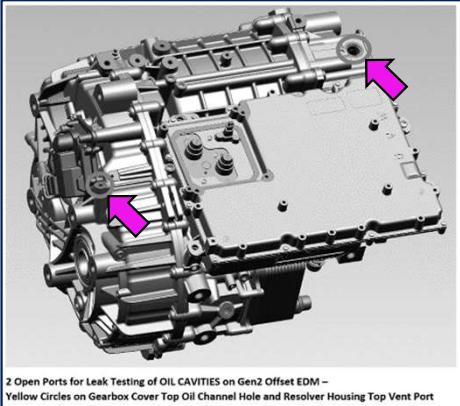
step 08



COVER ASSEMBLY

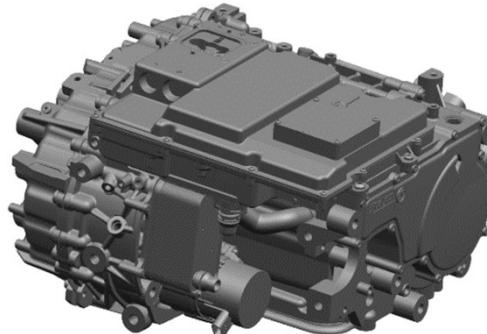
Test Loop (2/3)

step 09

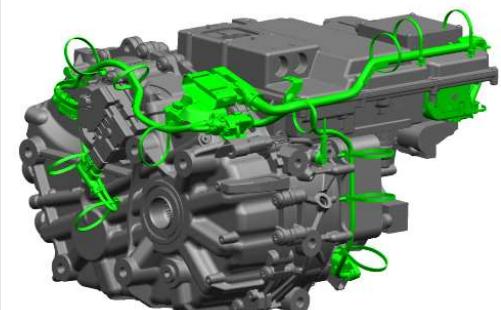


OIL AND WATER CIRCUIT LEAK TEST

step 10



step 11



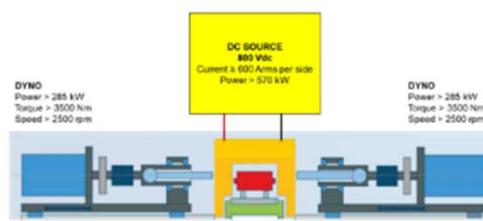
step 12

TEST

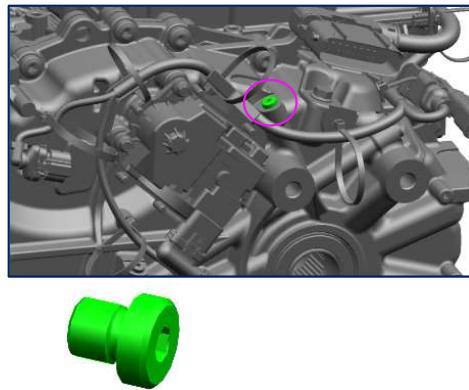
e.g.:

- INSULATION RESISTANCE (IR)
- PARK LOCK
- RESOLVER POSITION

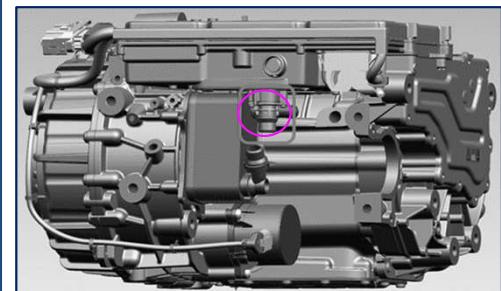
step 13



step 14



step 15



Test Loop (3/3)

step 16

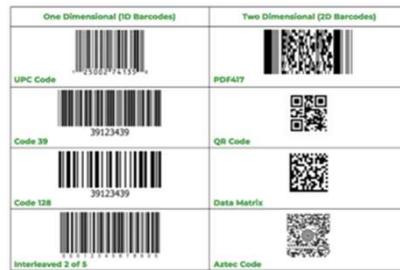
AUTO FLASH PIM
WITH FINAL VEHICLE

step 17

Auto grease cycle for differential shaft splines on both sides of assembly. Note different minor diameters of differential shaft internal splines based on low-torque 29T vs. high-torque 33T differential assemblies. (volume likely to be approximately 1.0 - 1.5 grams per side).

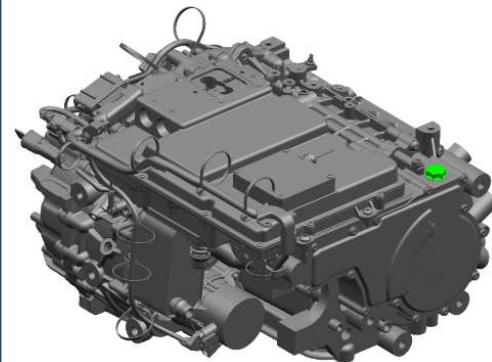
GREASING

step 18



LASER MARKING

step 19



VENT PORT PLUG CAP SCREWING

step 20

Shipping caps assembly on:

- PIM
- differential (after greasing) 2 caps
- coolant inlet
- coolant outlet
- breather vent/hole (if not installed)

Manual unload complete EDM assembly to shipping rack.

FINAL DRESSING AND UNLOAD