Oil Path Prediction and Optimization for High Speed Transmissions with ParticleWorks

EASY

to partner with

Elisabetta Fava

2018/10/08

comer industries

COMER INDUSTRIES

54 Countries

1362 Our people

7 Production plants in Italy, India, China

7 Subsidiaries in Europe, USA, Brazil, India, China

342,1 mln € Net Revenues 2017

WE ARE GLOBAL LEADERS IN MECHATRONIC SOLUTIONS AND INTEGRATED SYSTEMS FOR POWER TRANSMISSION

POWERTRAIN SYSTEMS

CONSTRUCTION EQUIPMENT

MATERIAL HANDLING

ROAD CONSTRUCTION MACHINERY

DRIVESHAFTS

FORAGE & HAY MACHINERY

AGRICULTURAL & GARDEN EQUIPMENT

PLANETARY DRIVES

MINING MACHINERY

CRANES & CONSTRUCTION EQUIPMENT

WIND TOWER GENERATORS

GEARBOXES

TRACTORS

COMBINED HARVESTERS & SELF PROPELLED MACHINES

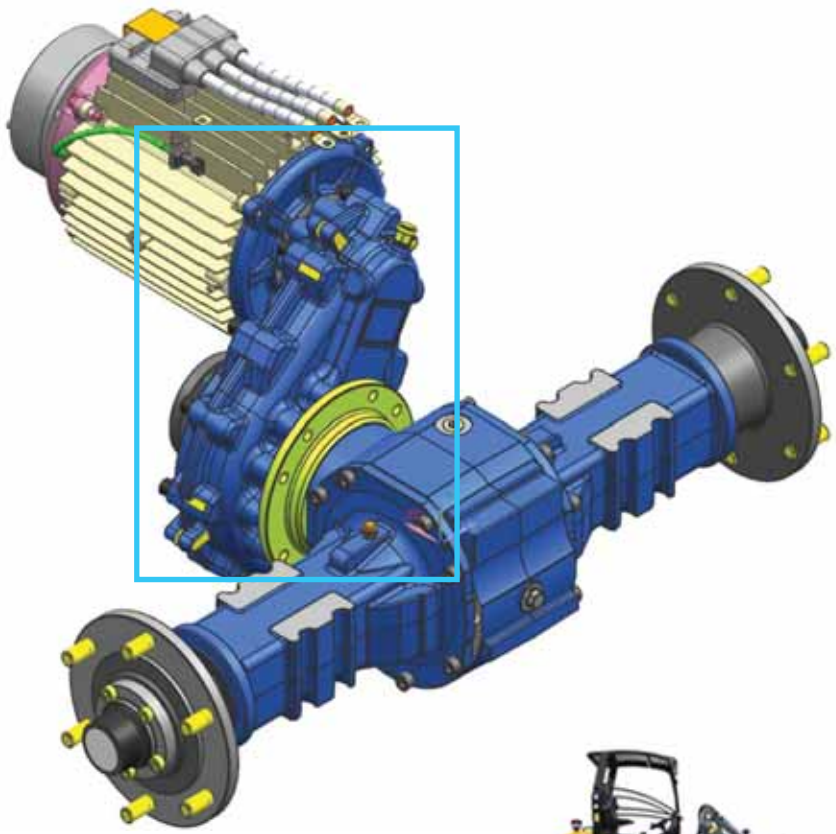
AGRICULTURAL MACHINERY & GARDEN EQUIPMENT

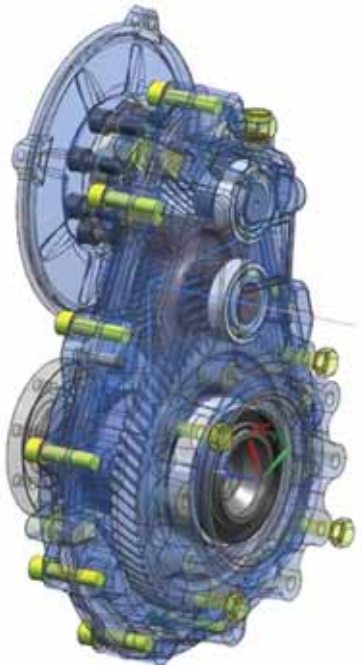
CASE STUDY

ELECTRIC MOTOR

COUPLING GEARBOX

AXLE





COUPLING GEARBOX DATA

- Overall ratio: 11,43
- Input speed: 700 - 6000 rpm
- Both cw and ccw sense of rotation
- 0° - 30° - 60° - 90° working positions

Application: WHEEL LOADER

TARGETS

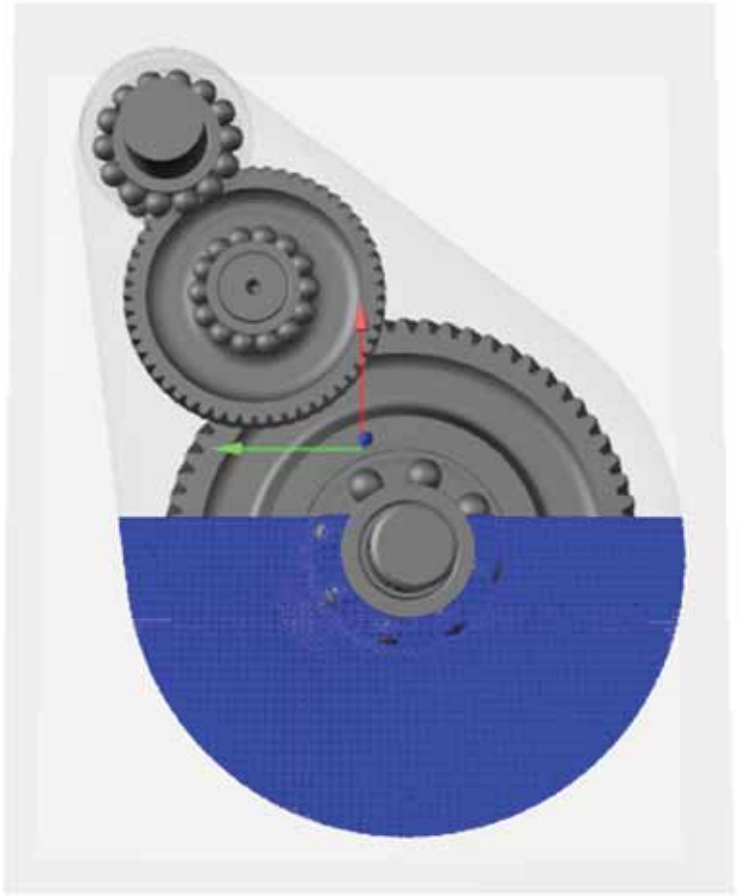
- **Proper lubrication** in each working position and for each input speed
- **Oil level optimization** to minimize power losses

MODEL BUILDING

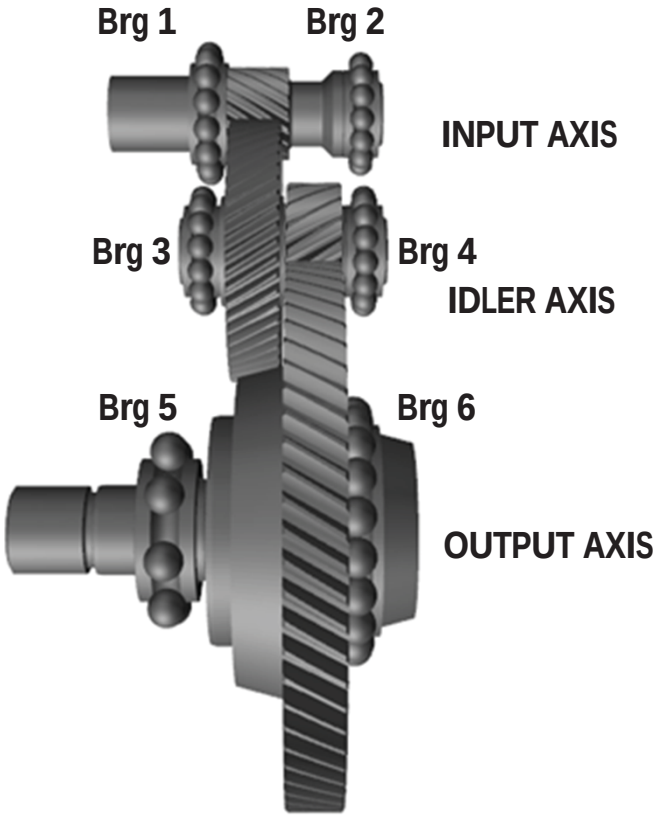
HOUSING INNER SURFACES

OIL DATA

- **T = 40°C**
- **ρ = 875 kg/m³**
- **v = 6,00 e-5 m²/s**
  60 cSt
- **γ = 0,03 N/m**
- **Oil qty = 1,00 l**



WORKING POSITION 30° TO VERTICAL



Case Studies	1	2	3	4	5	6
Input speed [rpm]	705	705	2500	2500	6000	6000
Sense of rotation	CW	CCW	CW	CCW	CW	CCW

MODEL SETUP

	Simulation Parameters	Simulated values
1	Courant Number	0,20
2	Speed of Sound [m/s]**	8
3	Turbulence	ON
4	Slip Factor	5
5	Particle Size [mm]	0,70
6	Pressure Smoothing	OFF
7	Surface Tension Model	Potential

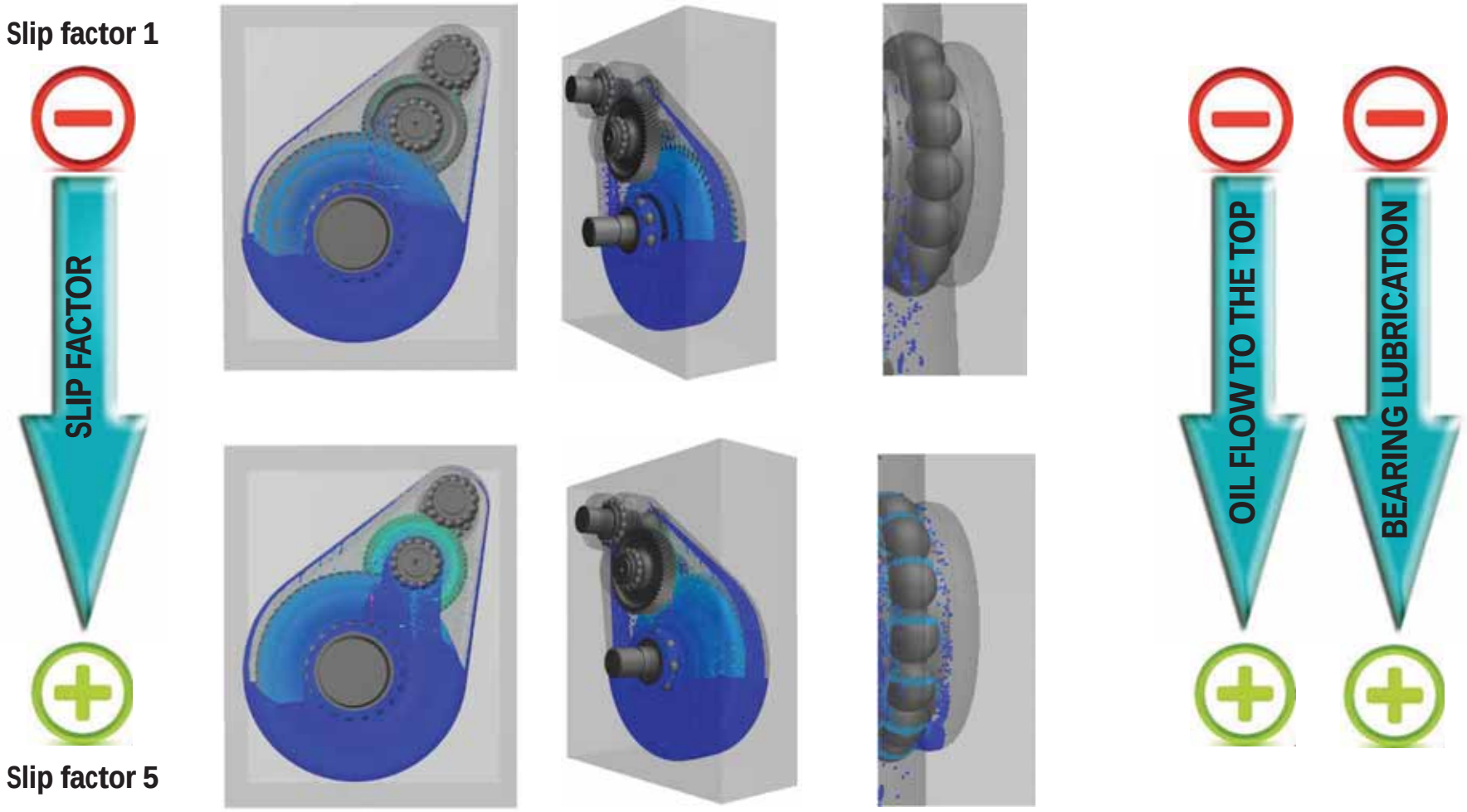
**calculated as 5*Tangential Speed max @ 705 rpm, applied at each speed

... SOME DATA ABOUT SIMULATION RUNS:

- **3.000.000 Particles**
- **Time steps from 8,5 E-05 to 1,0 E-05**
- **Simulation time : 2 simulation sec / 1 day on average**
- **Running on a NVIDIA K80 Graphic Card 12 GB GRAM**

Sensitiveness to the parameters 4, 5, 6 and 7 has been done to understand how they affect the oil path and, thus, to choose the best setup for the model

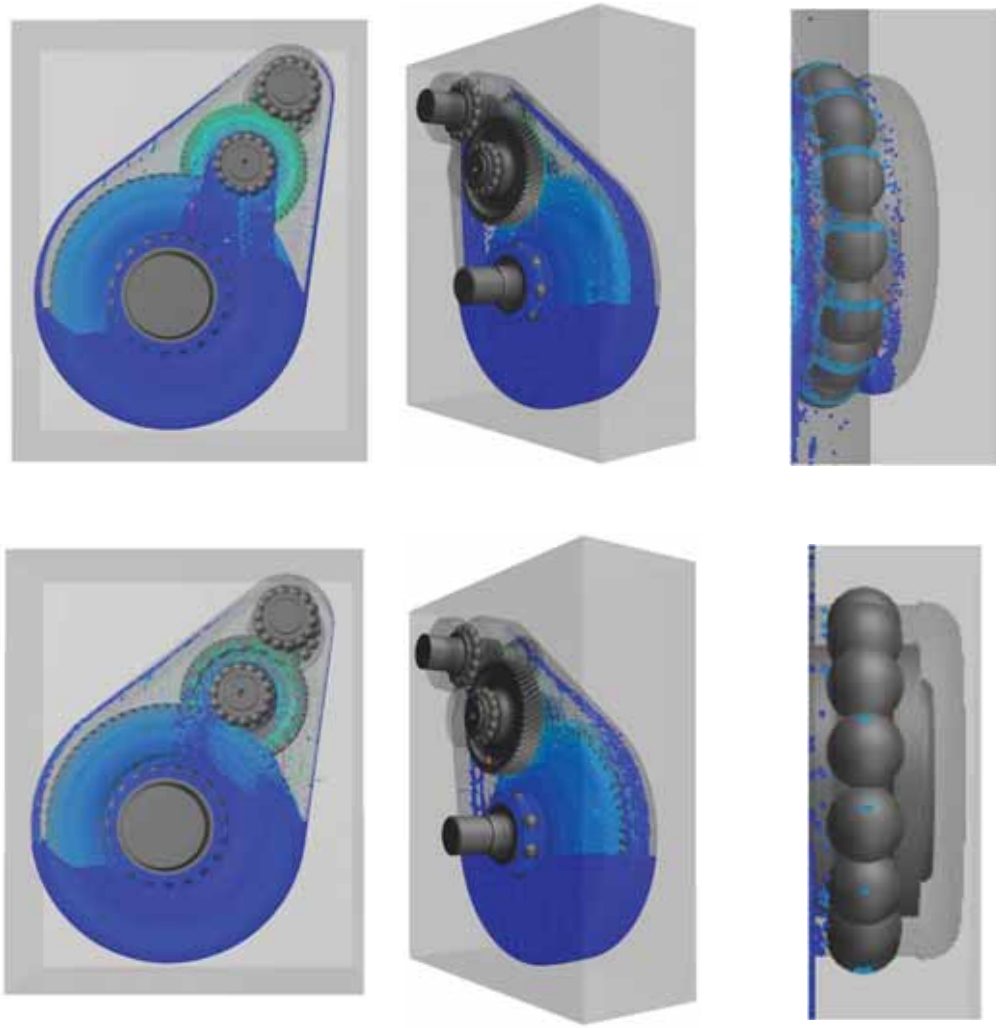
MODEL SENSITIVENESS

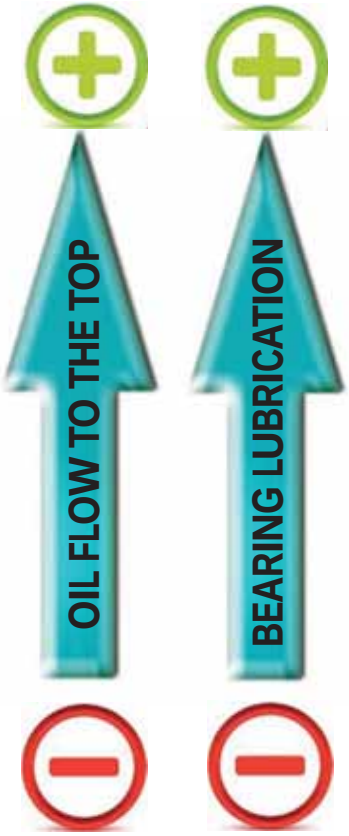


MODEL SENSITIVENESS

Particle size 0,7 mm

Particle size 1,0 mm

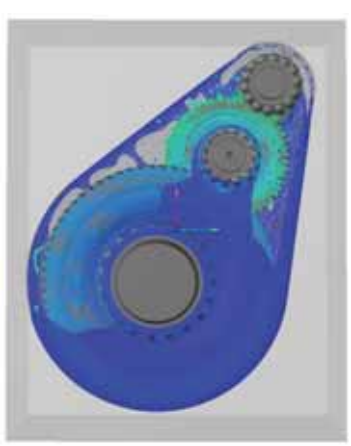
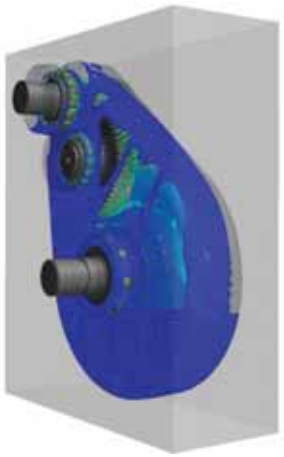
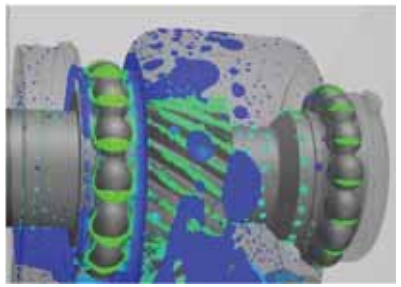


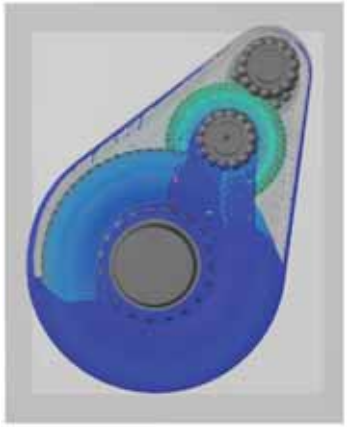
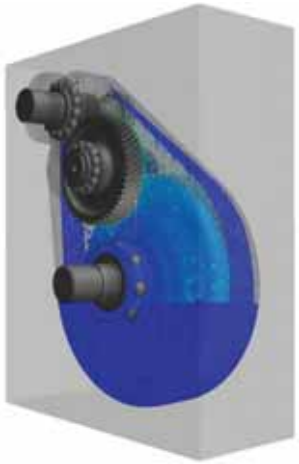
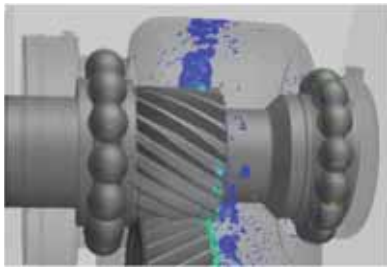


MODEL SENSITIVENESS

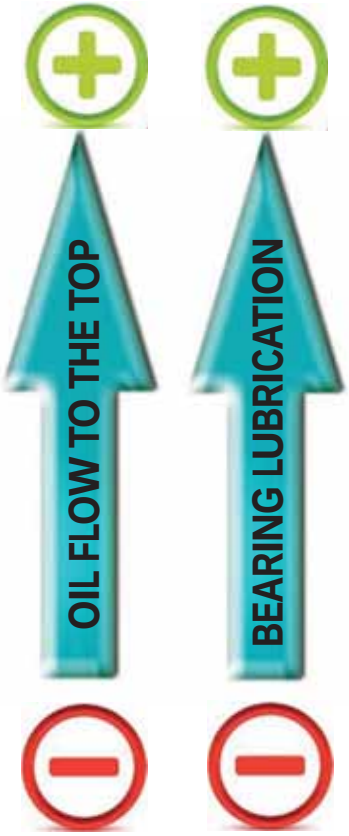
Pressure smoothing: OFF
Surface tension model: Potential

CALCULATION MODELS

Pressure smoothing: ON
Surface tension model: CSF



RESULTS

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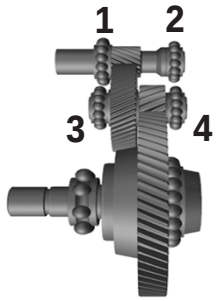

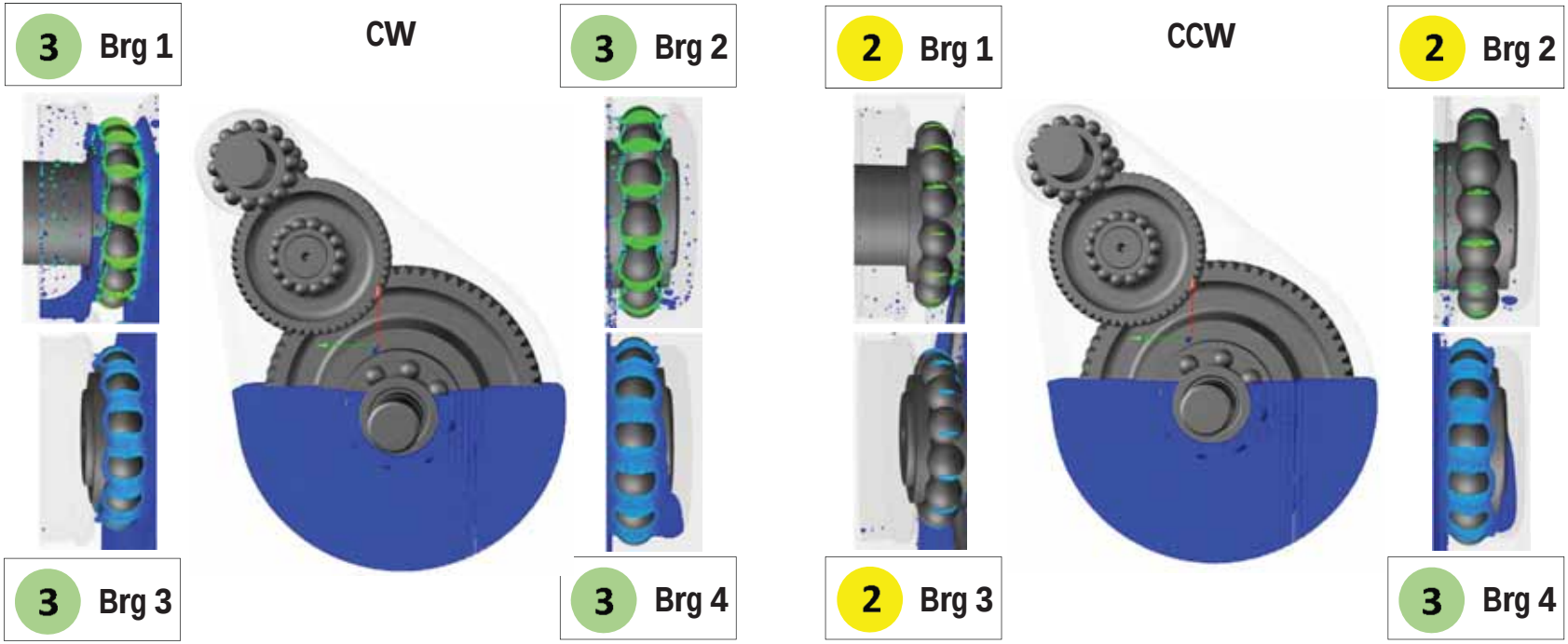

BEARINGS LUBRICATION LEVELS IN SIMULATIONS

1 — **NONE** - Single particles between rollers, no accumulation

2 — **POOR** - Groups of few particles between rollers, no accumulation

3 — **GOOD** – Good accumulation between rollers and beyond the brg

4 — **OPTIMUM** – Huge accumulation between rollers and beyond the brg

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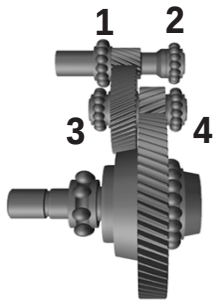

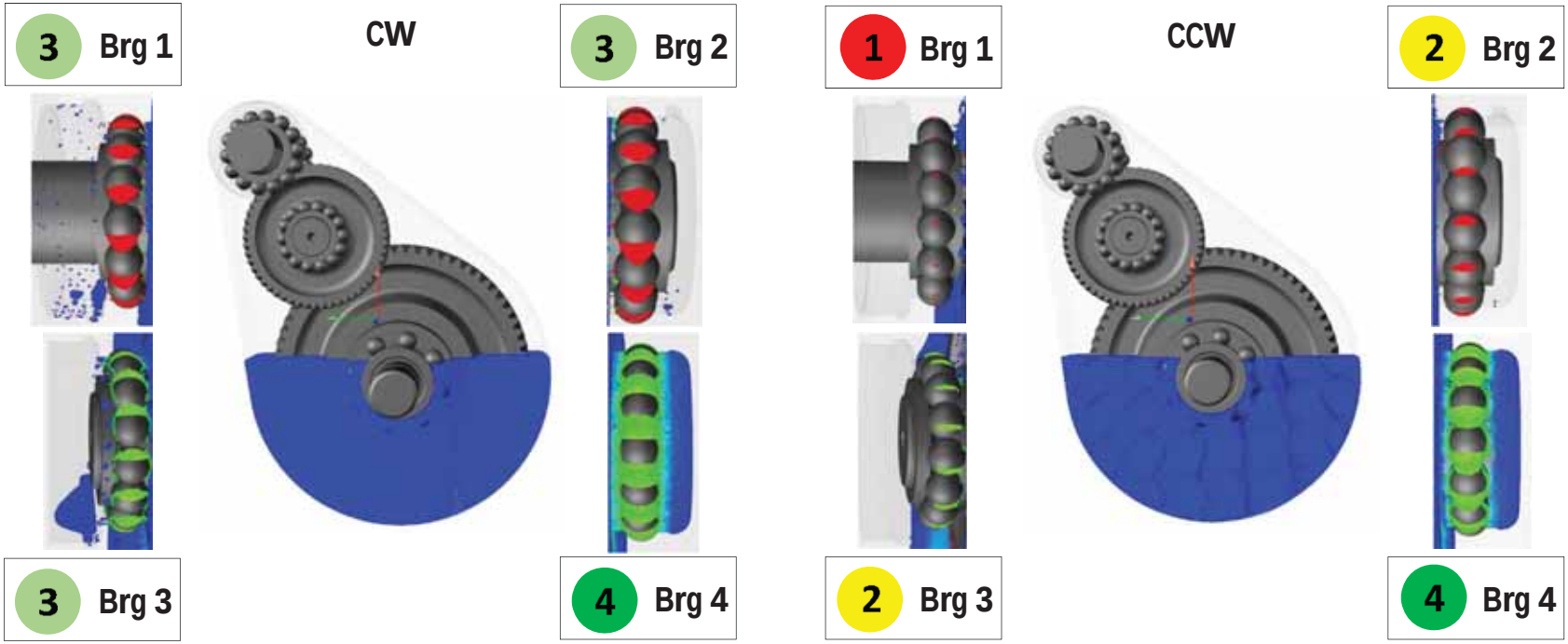

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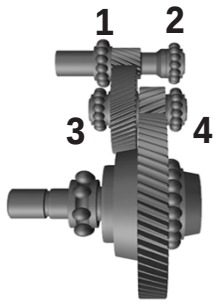

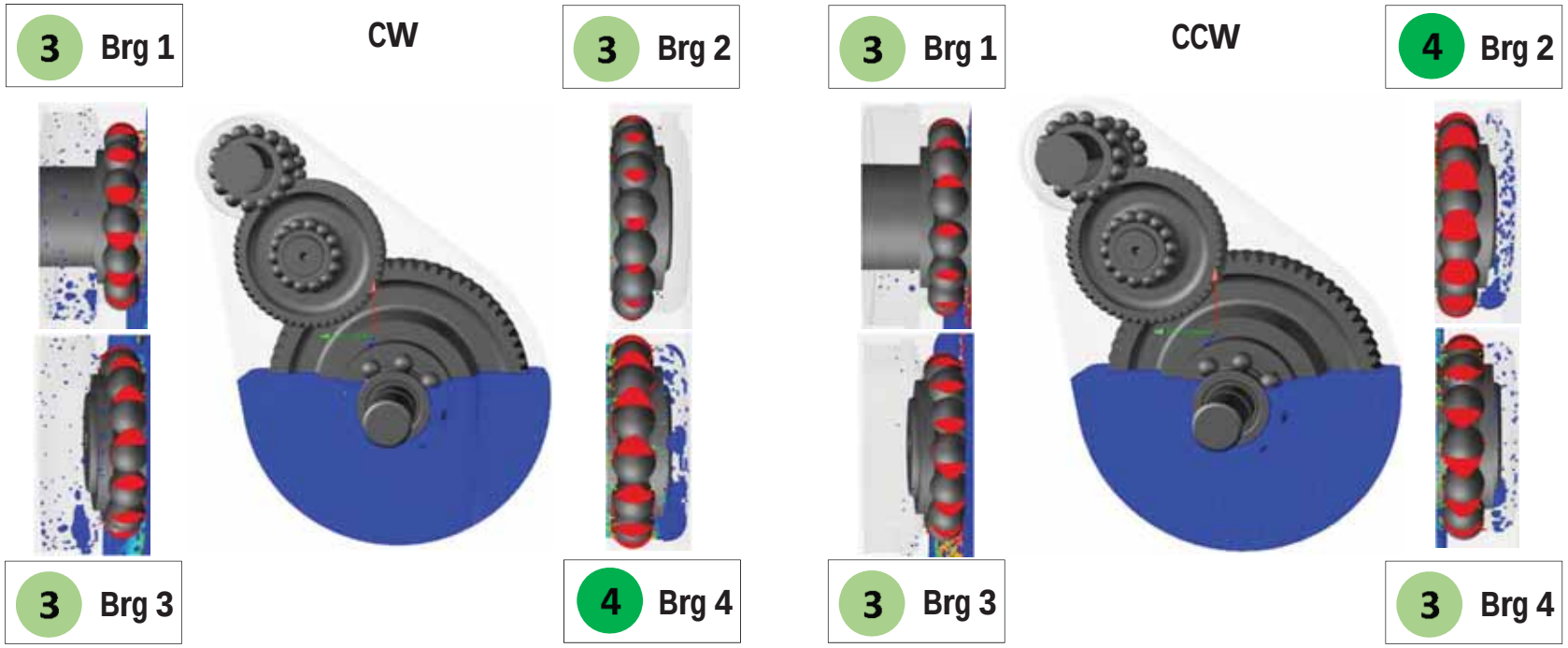

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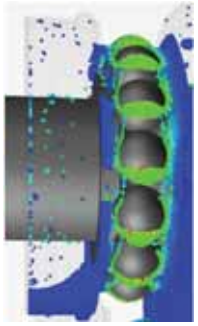
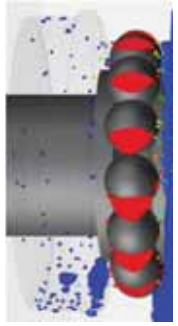
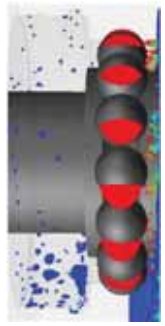
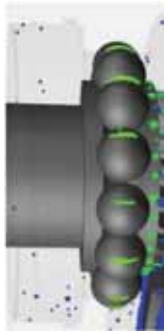
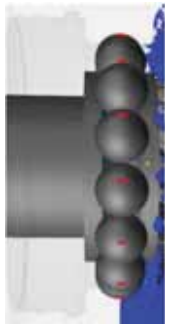
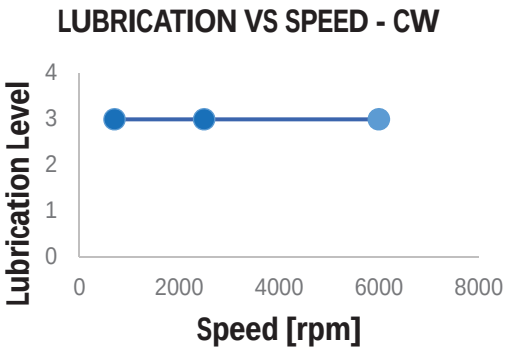
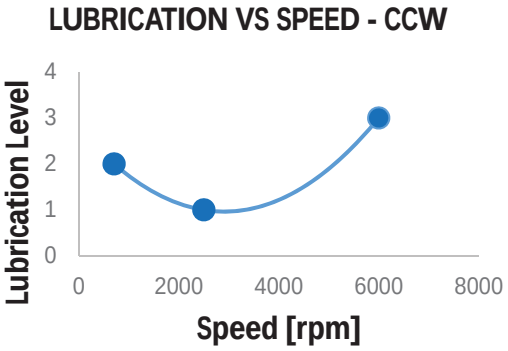
RESULTS

SPEED

	705 rpm	2500 rpm	6000 rpm
CLOCKWISE	3 Brg 1	3 Brg 1	3 Brg 1
			
CCW	2 Brg 1	1 Brg 1	3 Brg 1
			

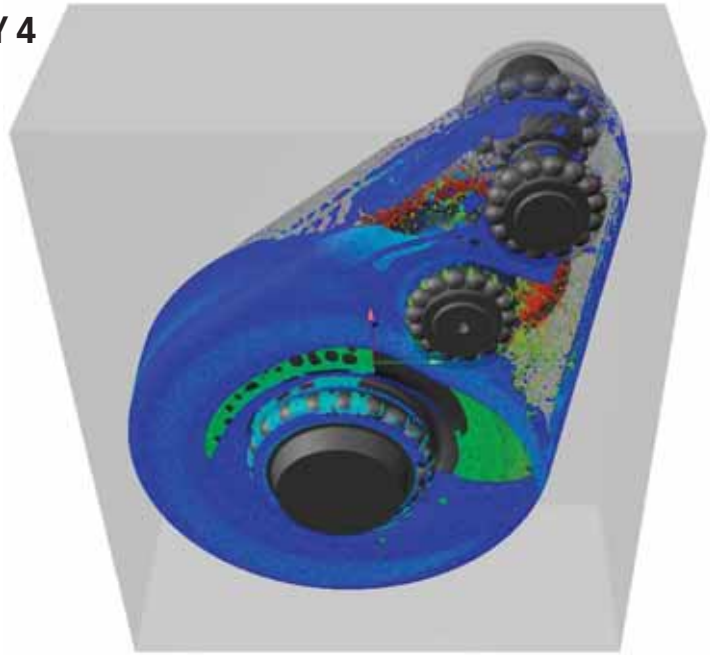




LUBRICATION LEVEL NOT PROPORTIONAL TO SPEED: MINIMUM @ 2500 rpm CCW

COMPARISON WITH TEST RESULTS

CASE STUDY 4
2500 rpm
CCW



BRG	Case Study 1 705 rpm CW		Case Study 2 705 rpm CCW		Case Study 3 2500 rpm CW		Case Study 4 2500 rpm CCW		Case Study 5 6000 rpm CW		Case Study 6 6000 rpm CCW	
	Simulation	Test	Simulation	Test	Simulation	Test	Simulation	Test	Simulation	Test	Simulation	Test
1	3	3	2	2	3	3	1	1	3	3	3	3
2	3	3	2	2	3	3	2	2	3	4*	4	4*
3	3	3	2	2	3	4	2	2	3	3	3	3
4	3	3	3	3	4	4	4	4	4	4*	3	4*
										*with foam		*with foam

SIMULATIONS

Single particles between rollers, no accumulation

Groups of few particles between rollers, no accumulation

Good accumulation between rollers and beyond the brg

Huge accumulation between rollers and beyond the brg

BEARINGS LUBRICATION LEVELS

1

2

3

4

TESTS

Only few drops out of the bearing during the rotation

Thin film during rotation or while the gearbox is stopping

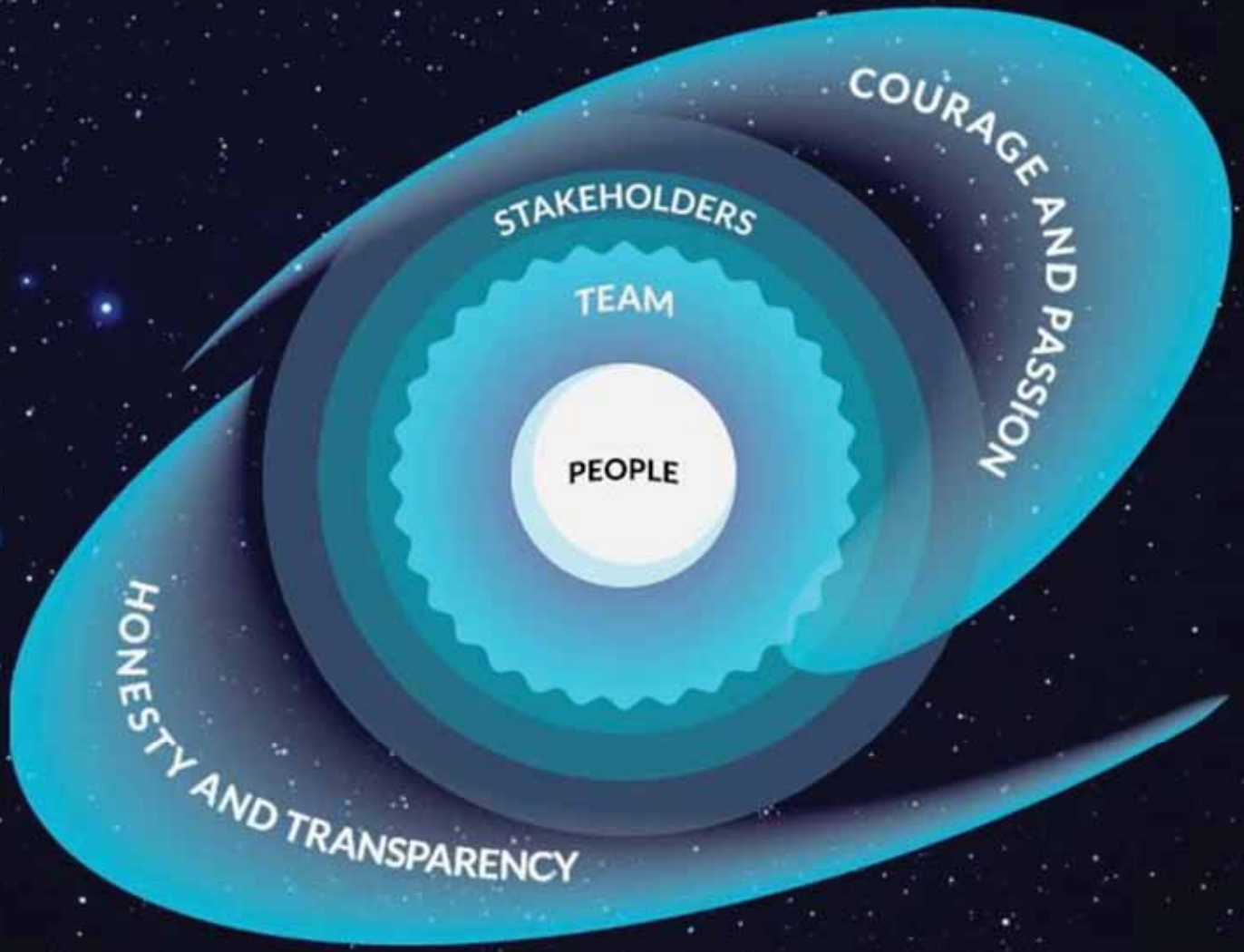
Thick film during the rotation, accumulation beyond the brg

Huge accumulation beyond the brg during the rotation

CONCLUSIONS

- A gearbox for high speed applications has been simulated to verify the proper lubrication of all the components
- Simulations have been done considering three input speed levels: 705 rpm, 2500 rpm, 6000 rpm and both the rotation direction, clockwise and counterclockwise
- While in the CW direction, the lubrication is properly distributed on all the bearings, in the CCW direction is poorer
- In the CCW direction, furthermore, the minimum oil quantity in the upper bearings is reached at an intermediate speed, while the oil quantity is greater at low and high speed
- A comparison with physical tests has been done: very good compliance between simulations and tests has been done both in terms of oil path description and oil quantity in the bearings. A slight difference has been detected at 6000 rpm, when the oil flow becomes foam.
- The compliance between simulations and tests has allowed to establish a qualitative scale of values for judging the lubrication levels tuned with the test scale
- Next steps: simulations with different housing geometry to guarantee lubrication with the same oil quantity
- Next steps: implementation of the air in the model in order to model the foam

OUR VALUES


COURAGE AND PASSION
STAKEHOLDERS
TEAM
PEOPLE
HONESTY AND TRANSPARENCY