

# 열역학 계산에 기반한 고온물성 모델링

# JMatPro

PRACTICAL SOFTWARE FOR MATERIALS PROPERTIES

- ✓ Fe alloys
- ✓ Aluminum alloys
- ✓ Nickel alloys
- ✓ Copper alloys
- ✓ Titanium alloys
- ✓ Magnesium alloys
- ✓ Cobalt alloy
- ✓ Zirconium alloys
- ✓ Solder alloys

## ■ JMatPro의 유일성!

"... 이 소프트웨어는 안정/준안정 상평형 계산, 응고 거동과 물성계산, 열-물리적 물성, 상변태 물성, Ni계 초합금, 철합금 등에 대한 기계적 강도 등의 계산이 가능한..... **유일한** 소프트웨어이다."

### ▶ 안정/준안정 상평형 계산

- 온도/농도 별 열역학계산
- 상태도 계산(Isopleth)

### ▶ 열-물리적 물성(온도 별 물성계산)

- 비열, 엔탈피
- 밀도, 열팽창계수, 프와송비
- 열전도도, 전기전도도/비저항
- 액상의 점도, 확산계수
- Young's/bulk/shear Modulus
- $\gamma/\gamma'$  mismatch
- 유도가열해석을 위한 자기 투자율

### ▶ 응고분율 및 물성 계산

- Scheil-Gulliver/Back Diffusion 모델
- 균질화 열처리(Homogenization) 계산
- 응고과정의 열-물리적 물성 계산
- 주철에서는 고상에서의 상변태 계산

### ▶ 기계적 물성

- 상온/고온 항복강도, 조미니 경화능 선도
- 온도/변형률속도 별 유동응력 선도
- 주조강도, FLD, 파괴인성, 크립수명
- T4/T6, T5, T8, O, F, H 열처리 강도 계산(Al합금)

### ▶ 상변태 물성

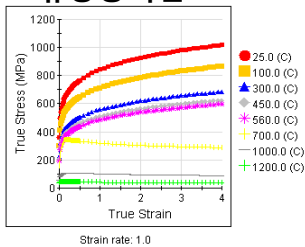
- TTT/CCT/TTA/TTP 선도
- 퀴칭 및 가열시 열-물리적 물성 변화
- 템퍼링 공정 석출상 생성과정 및 경도
- Ar1, Ar3, Ac1, Ac3 온도 계산
- 용접 사이클에서의 물성 거동
- 니켈 합금에서의  $\gamma' / \gamma''$  coarsening
- 이종 재질 용접시 경계부 확산 프로파일

### ▶ 공정 시뮬레이션을 위한 물성 계산

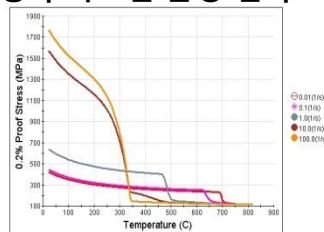
- 열처리/주조/열간성형/용접/유동/열전달 상용S/W를 위한 물성 파일 생성

## JMatPro V14 계산 사례

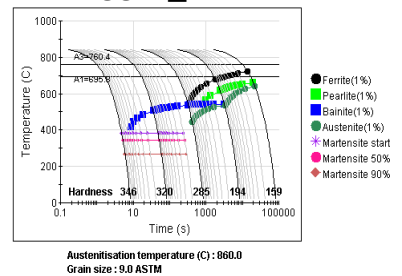
유동응력선도



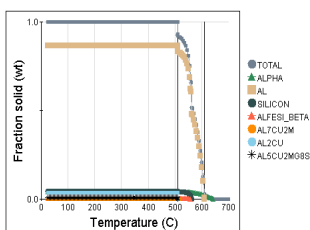
냉각 속도별 물성 변화



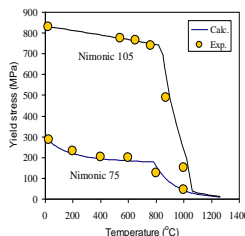
CCT 선도



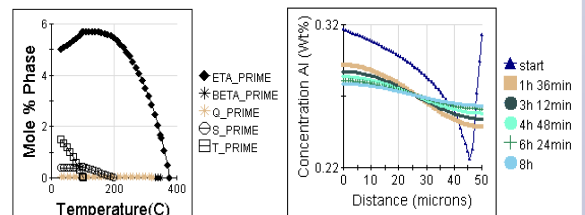
온도별 응고분율



석출상에 의한 강도 변화



준안정상 계산 및 균질화 모델링



Version 14.0 (Data export to 3 <sup>rd</sup> party simulation S/W) (Additional API module available)***		Al alloys	Mg alloys	Cast Iron	General Steels	Stainless Steels	Ni alloys	Co alloys	Ti alloys	Zr alloys	Solder alloys	Copper alloys
Phases	Temperature/Concentration stepping	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Isoleth	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Metastable phases	✓	✓									
Physical properties	Standard physical properties*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Stacking fault energy				✓	✓	✓	✓				
	Gamma/Gamma' mismatch						✓					
	Magnetic permeability				✓							
Solidification	Phases and physical properties	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Back diffusion/Secondary dendrite arm spacing	✓	✓		✓	✓	✓	✓	✓	✓		
	Cooling curve	✓	✓	✓			✓	✓	✓	✓	✓	✓
	Cast Strength	✓	✓	✓	✓							
	Homogenisation	✓	✓		✓	✓	✓	✓	✓	✓		
Mechanical properties**	O F H T5 T4/T6 T8 Heat treatment strength	✓										
	Room temp strength/hardness	✓			✓	✓	✓		✓			
	High temp strength/hardness	✓			✓	✓	✓	✓	✓			
	Flow-stress curve & rupture strength	✓	✓		✓	✓	✓	✓	✓			
	Creep and rupture life					✓	✓	✓	✓			
	Jominy hardenability				✓							
	Fatigue tool				✓	✓	✓	✓	✓			
	FLD/Processing Map	✓	FLD		✓	✓	✓	✓	✓			
Fracture toughness	✓			✓				✓				
Phase transformations	TTT/CCT diagram	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	TTA diagram				✓							
	Reaustenitisation phases and properties				✓							
	Plasticity coefficients				✓							
	Isothermal transformations	✓	✓		✓	✓	✓	✓	✓	✓		
	Energy changes			✓	✓	✓	✓		✓			
	Cooling transformations				✓				✓	✓		
	Martensite formation				✓	✓			✓			
	Stress induced martensite				✓	✓						
	Quenching and welding data				✓							
	Simultaneous carbide precipitation/strength				✓							
	Temperature-time-precipitation of M(C,N), MN, AlN				✓	✓						
	Tempering hardness and properties				✓							
	Gamma/Gamma" coarsening						✓					
Hot Rolling grain size/recrystallization/rolling force				✓								
Evolution of microstructure & strength						✓						
Data export	Forging simulation data	✓			✓	✓	✓	✓	✓			
	Welding and heat treatment simulation data				✓							
	Solidification simulation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Other	Carburisation				✓	✓						
	C diffusion in weld				✓							
	Dissimilar metal welds	✓					✓		✓			
	Pitting resistance					✓						

\* Specific heat – enthalpy - density - molar volume - thermal expansion coefficient - thermal conductivity - electrical conductivity/resistivity - surface tension - liquid viscosity/diffusivity- Poisson's ratio- Young's/shear/bulk modulus. These properties can be calculated during/after heat treatment or during solidification for the whole temperature range including liquid phase. When relevant, properties are given for each phase.

\*\* Proof stress, tensile stress and hardness are calculated at any temperature up to the melting point.

\*\*\* It allows you to automate and develop tasks within your own models and to integrate them into your own software via c/c++ programming.