

# **Solutions for Hydrogen-Induced Delayed Fracture in Hot Stamping**

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# 1. BACKGROUND

Last 10 years

Safety

Environmental  
Protection

Comfortable

Auto trend



What for these?

Nowadays

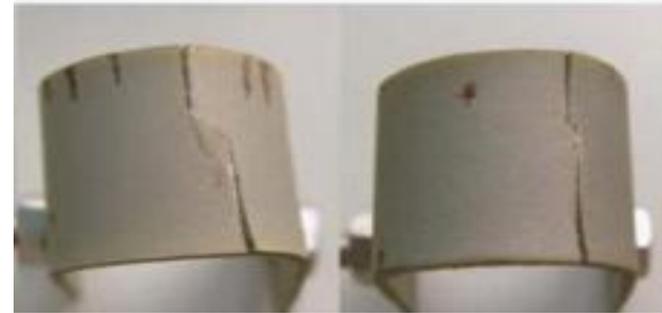
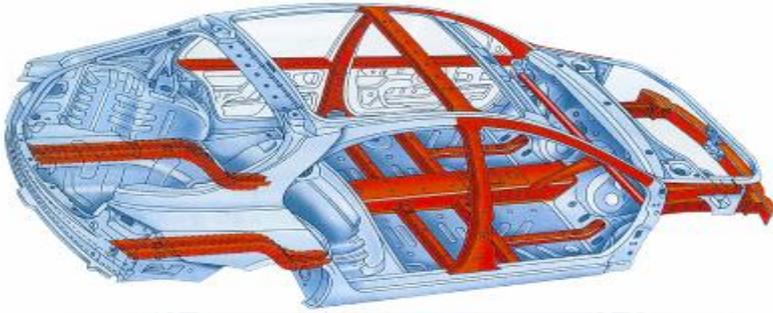
New Energy  
Vehicles

Lightweight

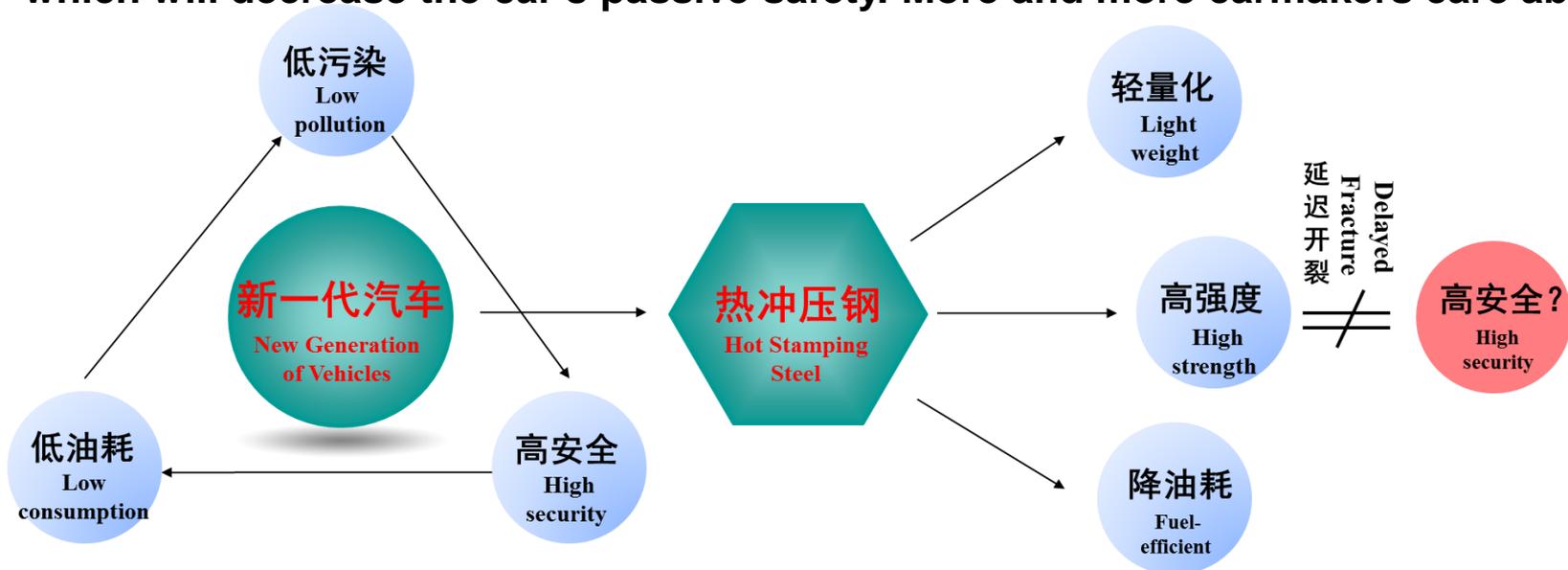
Intelligent Car

□ To accomplish this goals, press-hardening steel and hot stamping parts have been used in car body.

# 1. BACKGROUND



□ The possibility of hydrogen-induced delayed fracture (HDF) of hot stamping parts exists, which will decrease the car's passive safety. More and more carmakers care about it!



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**RECEARCH PROGRESS**

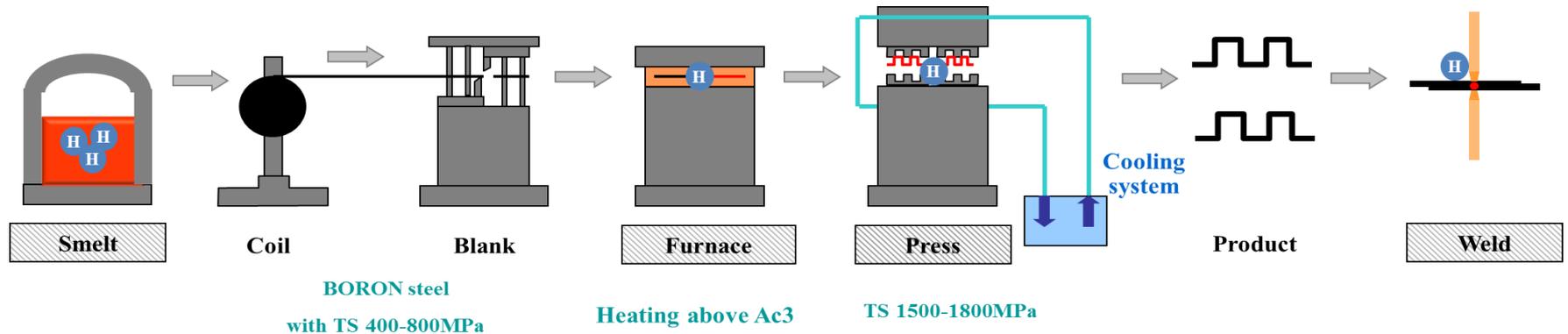
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DISCUSSTION AND SUGGESTIONS

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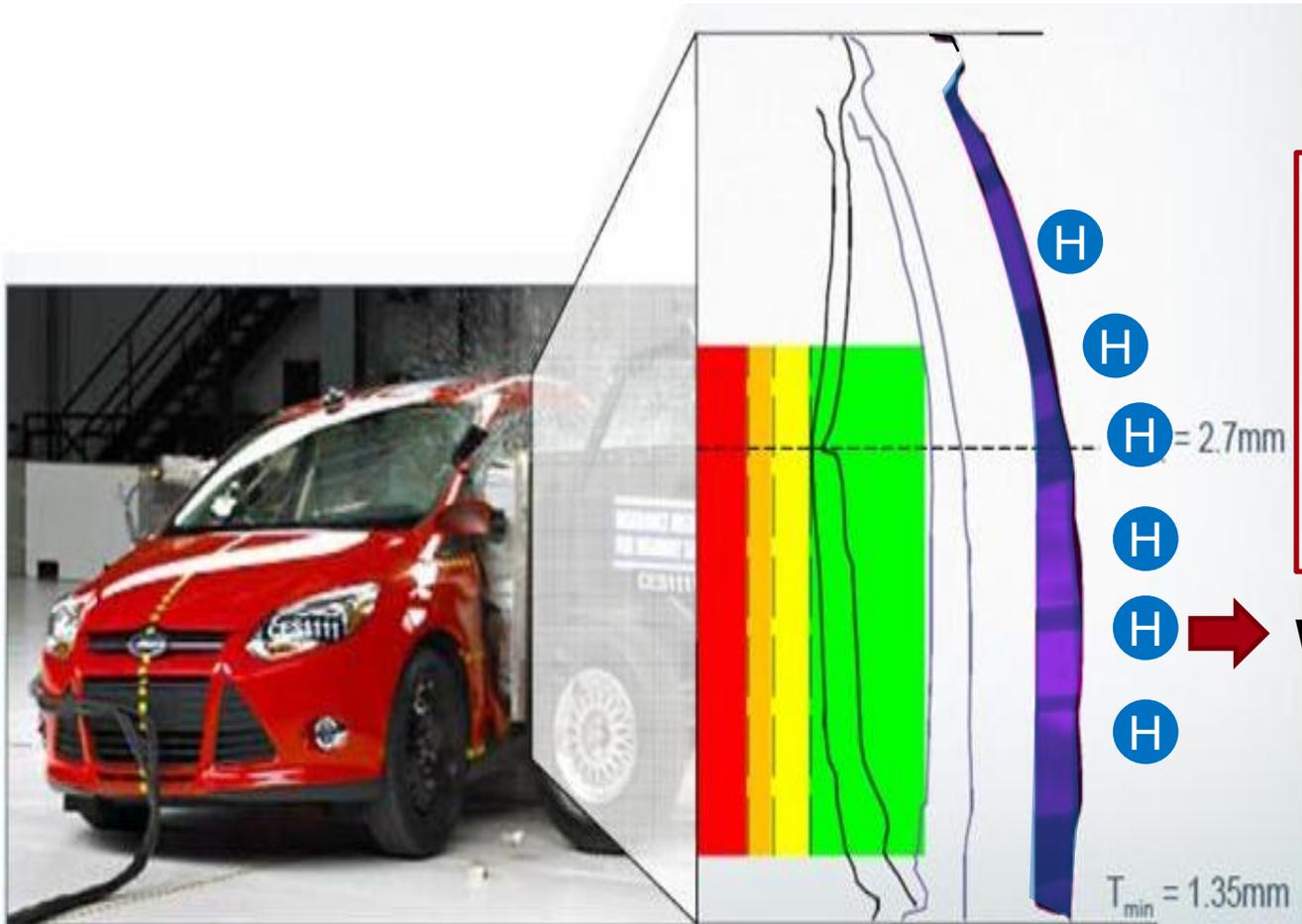
CONSLUTIONS

## 2. RESEARCH PROGRESS



- ❑ Smelt of PH steel
- ❑ Austenitizing of PH steel in furnace
- ❑ Pressing in tools
- ❑ Welding process of parts
- ❑ Car in service

## 2. RESEARCH PROGRESS



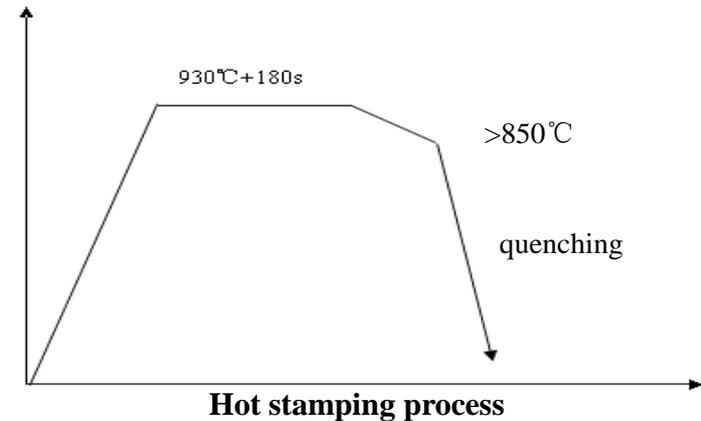
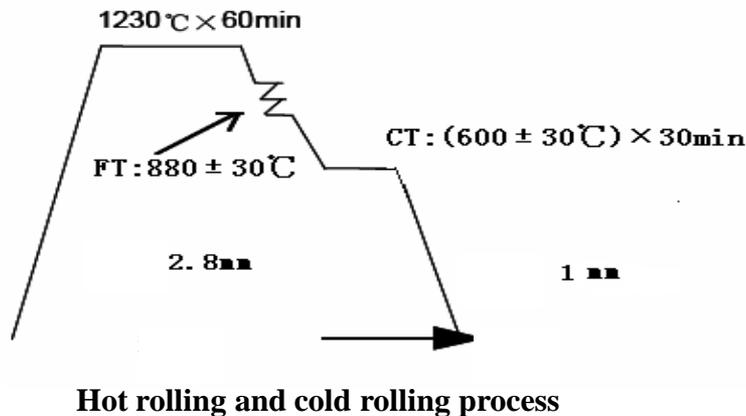
□ Once the hydrogen content in components is more than some critical value, the components will crack at low stress.

→ We need a solution!!!



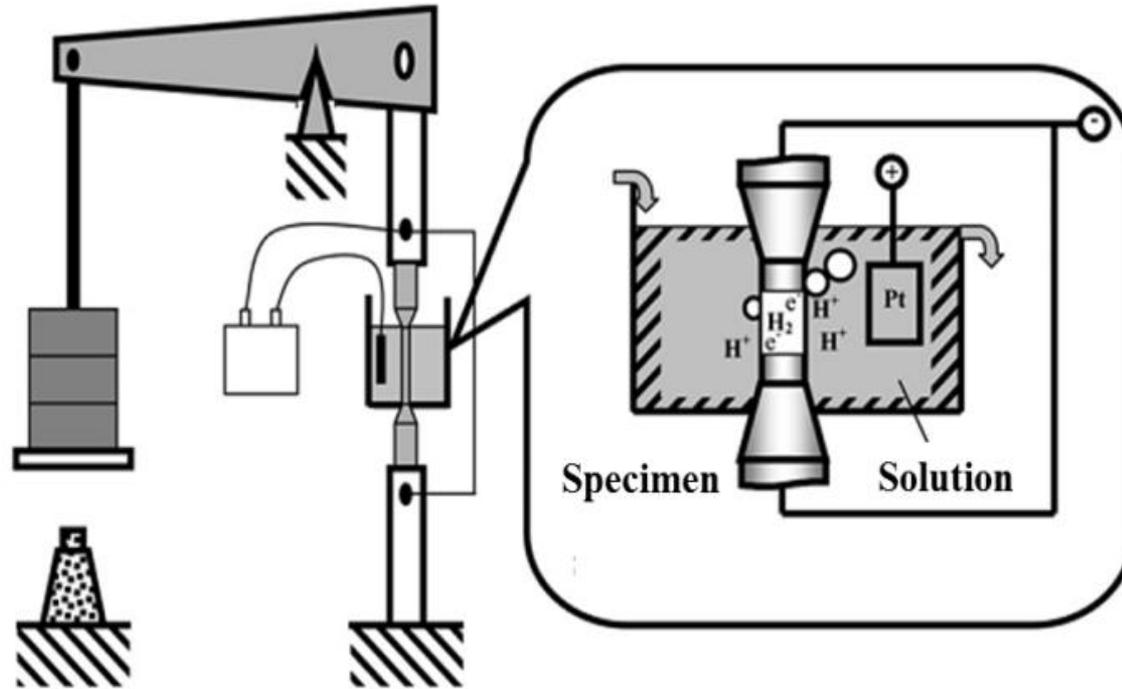
## 2. RESEARCH PROGRESS

Steel	C	Si	Mn	Ti	Cr	B	Nb
22MnB5	0.25	0.32	1.20	0.030	0.17	0.0022	—
22MnBNb2	0.24	0.33	1.17	0.031	0.16	0.0028	0.022
22MnBNb5	0.23	0.33	1.18	0.033	0.17	0.0025	0.053
22MnBNb7	0.23	0.31	1.29	0.029	0.20	0.0025	0.072



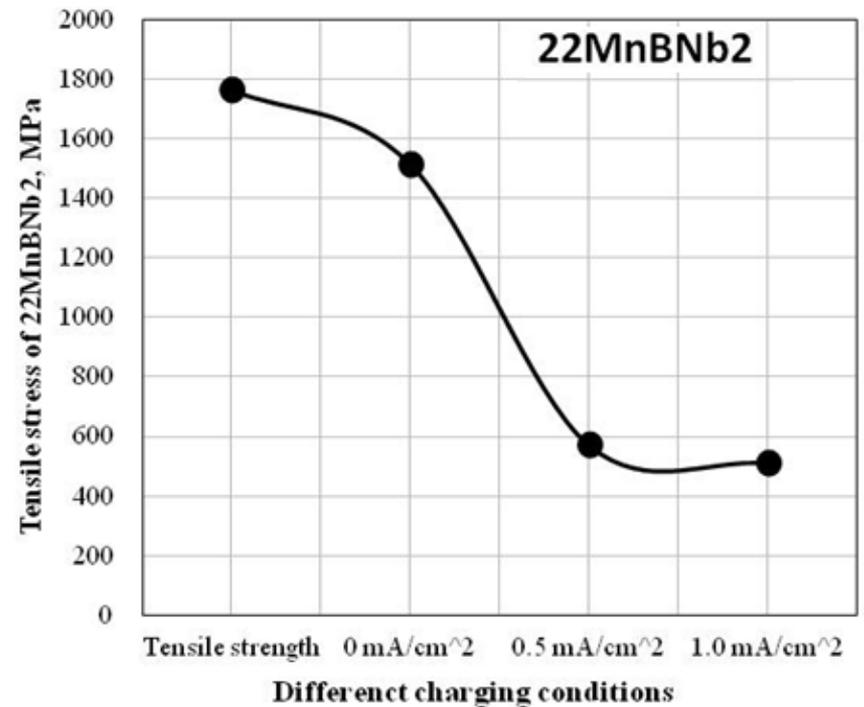
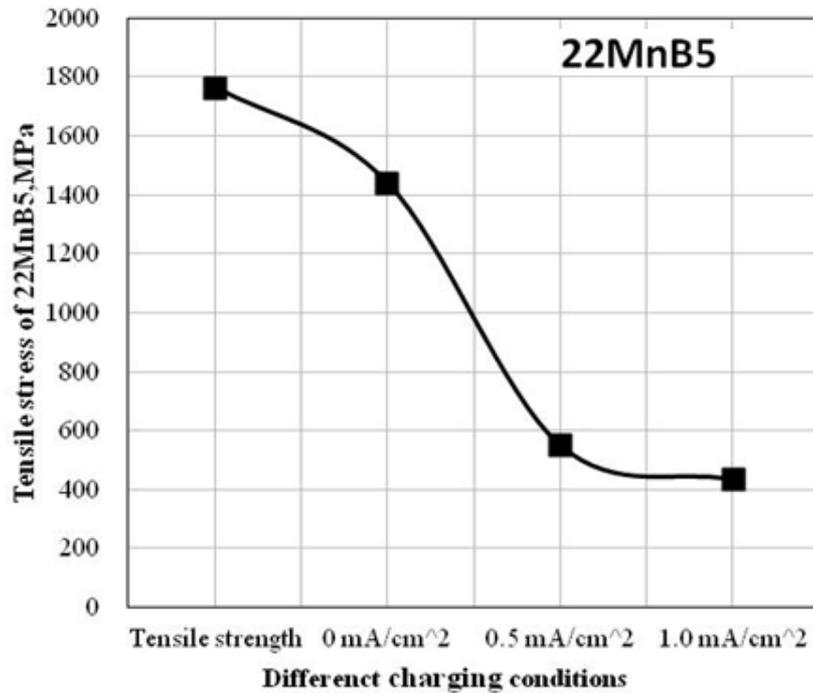
□ Then the specimens were heated up into austenite region at  $930\text{ }^{\circ}\text{C}$ , held for 3 min, and deformed while water quenching.

## 2. RESEARCH PROGRESS

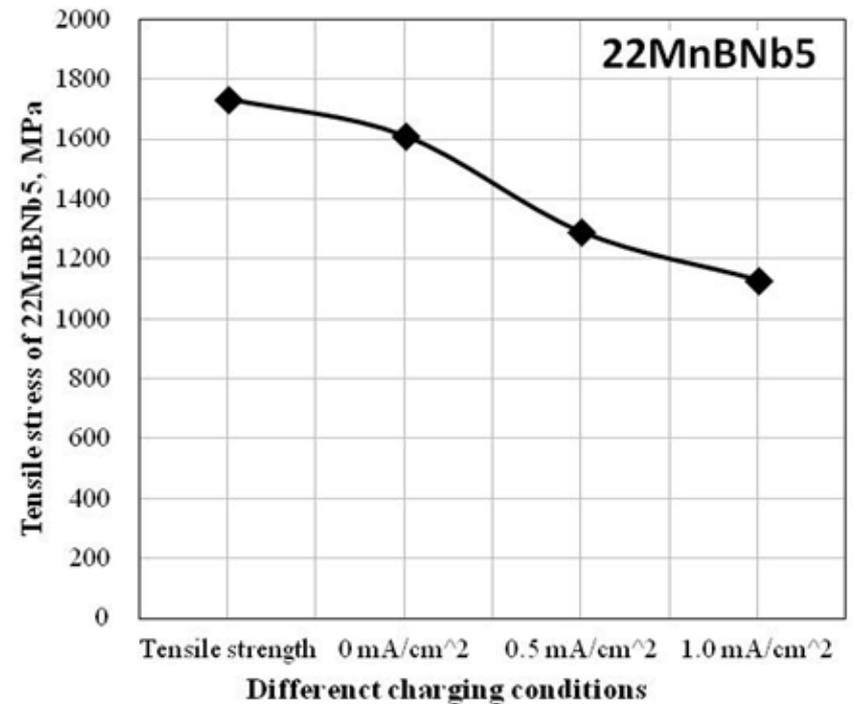
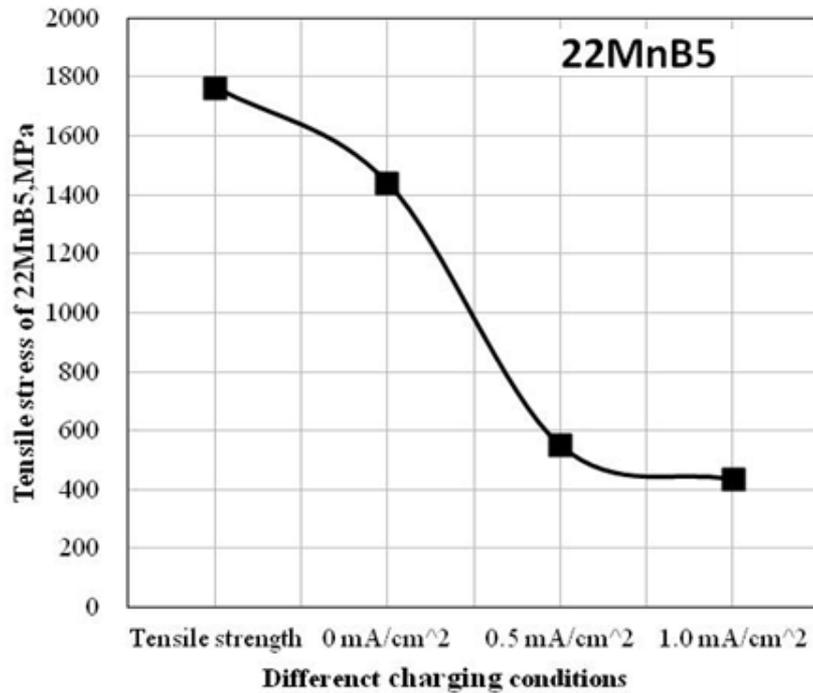


Diagrammatic sketch for constant load test

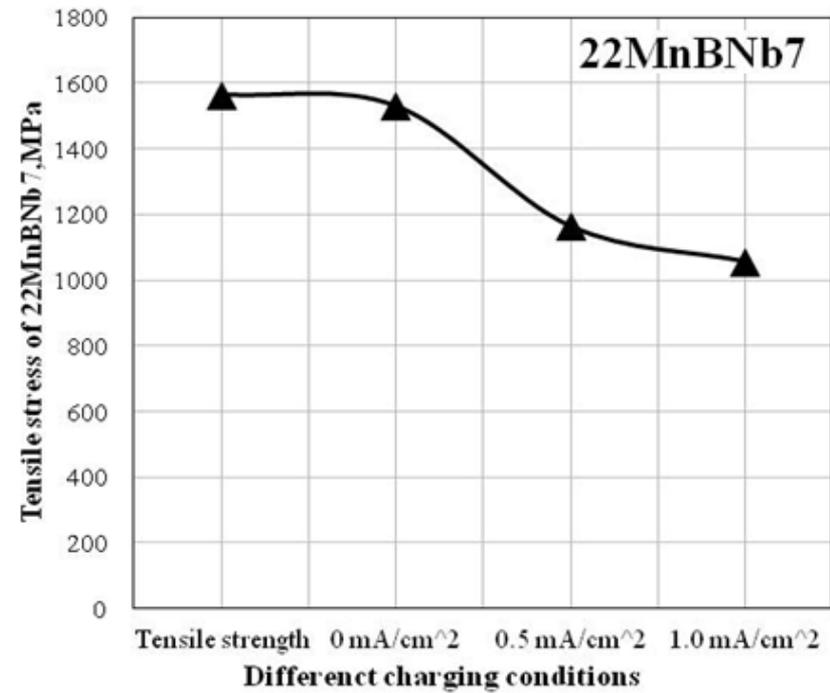
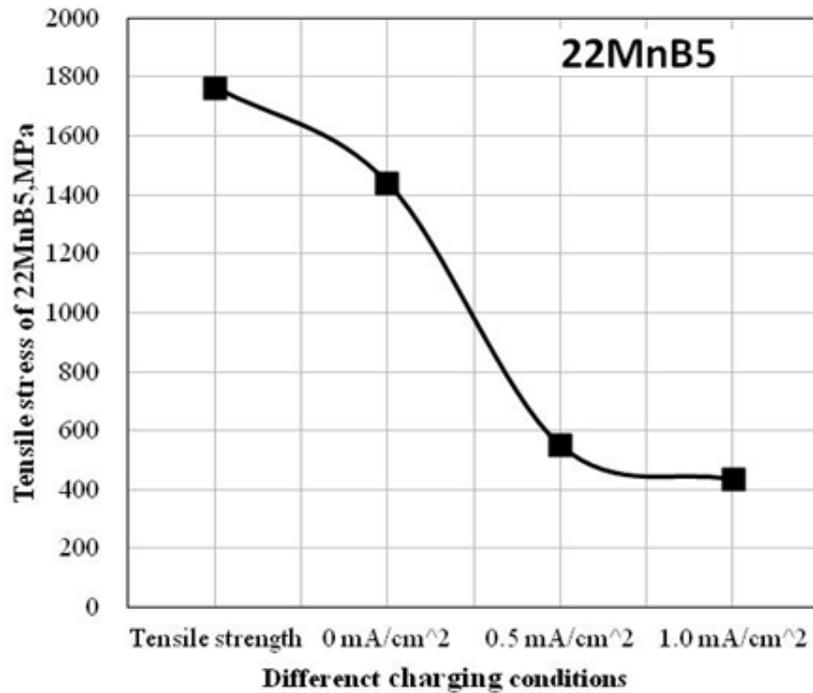
## 2. RESEARCH PROGRESS



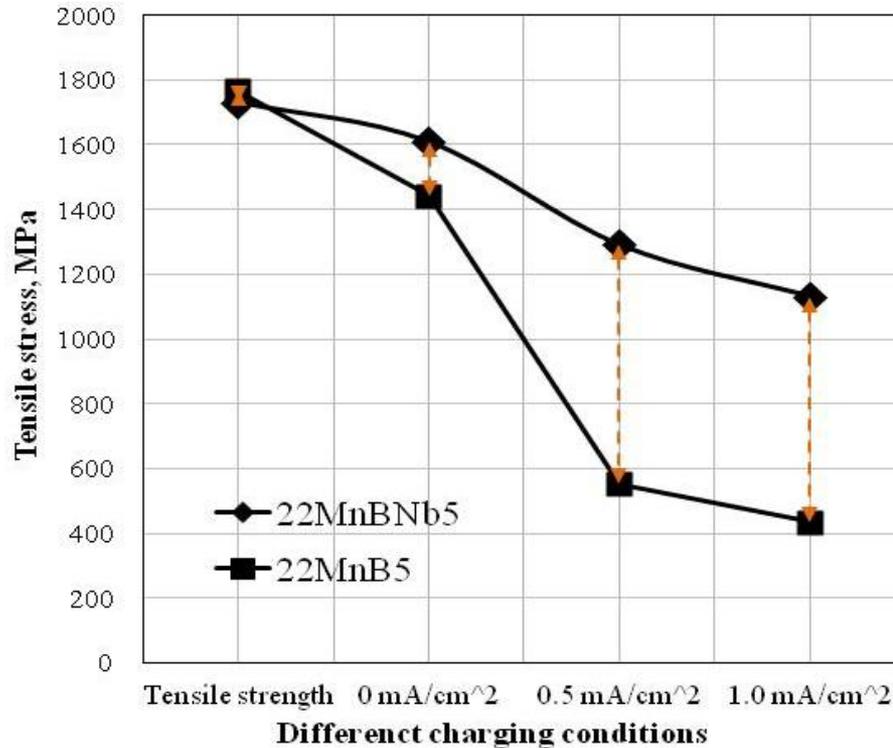
## 2. RESEARCH PROGRESS



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## 2. RESEARCH PROGRESS



→Nb improves the HDFR

- ❑ When the current density is 0.5mA/cm<sup>2</sup>, the critical delayed fracture stress of traditional 22MnB5 decreases so much, and variation of reduction of delayed fracture strength of 22MnB5 is about 1000MPa, it means that a hydrogen-induced brittle fracture happens due to the hydrogen.
- ❑ However, when the current density is 0.5mA/cm<sup>2</sup>, the critical delayed fracture stress of traditional 22MnBNb5 is about 1300MPa, and variation of reduction of delayed fracture strength of 22MnB5 is only about 400MPa.

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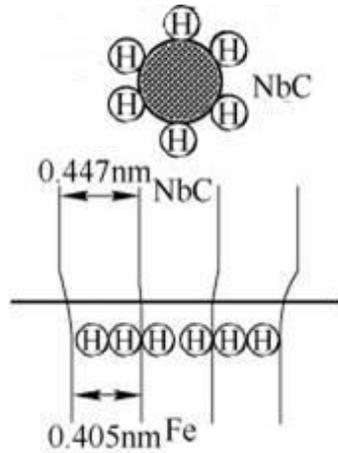
**DISCUSSTION AND SUGGESTIONS**

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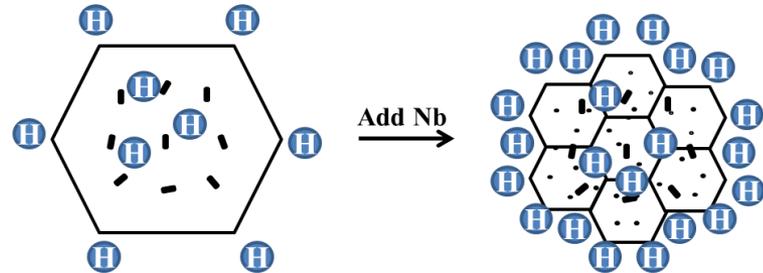
CONSLUTIONS

### 3. DISCUSSTION AND SUGGESTIONS

Mechanism 1: Hydrogen trap effect of NbC.



Mechanism 2: Grain refinement effect of Nb.



□ Some trapping, such as second phases particles( TiC and Fe<sub>3</sub>C), interact strongly with hydrogen and lead to the uniformly distributed of hydrogen in steel. NbC may also belongs to this trapping.

□ The dispersive distribution of the fine Nb(C,N) particles in steels increase the effective area of grain boundary by reducing the grain size and thus enable the well-distribution of hydrogen trapping and inhibit the spread of hydrogen to the crack tip. So the delayed fracture resistance of steel is improved by the improvement of the trap amount of grain boundary.

### 3. DISCUSSTION AND SUGGESTIONS

- ❑ The solution for hydrogen-induced delayed fracture in hot stamping is clear, which is the new chemical composition 22MnBNb5.
- ❑ And what we suggest that carmakers can underatood this, and optimaze the hot stamping process with this solution. Steelmakers should follow this trend.
- ❑ Actually, almost 1800MPa PH steel has used this solution.



### 3. DISCUSSTION AND SUGGESTIONS

<i>Effect of Nb in auto steel</i>	<i>High Strength Steel</i>	<i>How to reduce the weight</i>	<i>Assembly or parts</i>
Improve the strength	HSLA Dual-phase steel High Strength IF steel TRIP steel	Reduced thickness of parts	Car body
Improve the formability: Improve hole expanding Improve bendability	Dual-phase steel Multiphase steel Press hardening steel	Optimized the geometry of parts to enhance the moment of inertia, improved the stiffness of parts, and reduced thickness of parts	Car body Seat frame Wheels Chassis
Reduce the sensitivity of hydrogen embrittlement	Press hardening steel Martensite steel	Applied 1500MPa and 1800MPa hot press forming parts, reduce thickness of parts	Car body
Improve the weldability	Dual-phase steel Multiphase steel Press hardening steel TRIP steel	Reduced the carbon equivalent, keep the strength, then reduce the welding cost and improve the qualification rate	Car body Wheels
Improve the surface quality of coatings	Hot Dip Galvanized IF steel	Improved the qualification rate	Car body

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### 3. CONSLUTIONS

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- **We found a solution for hydrogen-induced delayed fracture in hot stamping**
- ◆ (1) New press-hardening steel 22MnBNb2, 22MnBNb5 and 22MnBNb7 are studied, and 22MnBNb5 and 22MnBNb7 have better hydrogen delayed fracture resistance than traditional 22MnB5.
- ◆ (2) The appropriate addition of Nb(0,05%) is beneficial to the improvement of the hydrengeen delayed fracture resistance of high strength hot stamping steel.
- ◆ (3) Niobium Microalloying Technology is a important solution for hydrogen-induced delayed fracture in hot stamping.

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*Thanks for your attention!*

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