

ANKIROS 2010

DESIGN OF DIE CASTING METHOD FOR PRODUCTION OF DETAILED WEAPON PARTS UNDER HIGH IMPACT LOADINGS



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Outline:

Aim

Introduction

Experimental Method

Results & Discussion

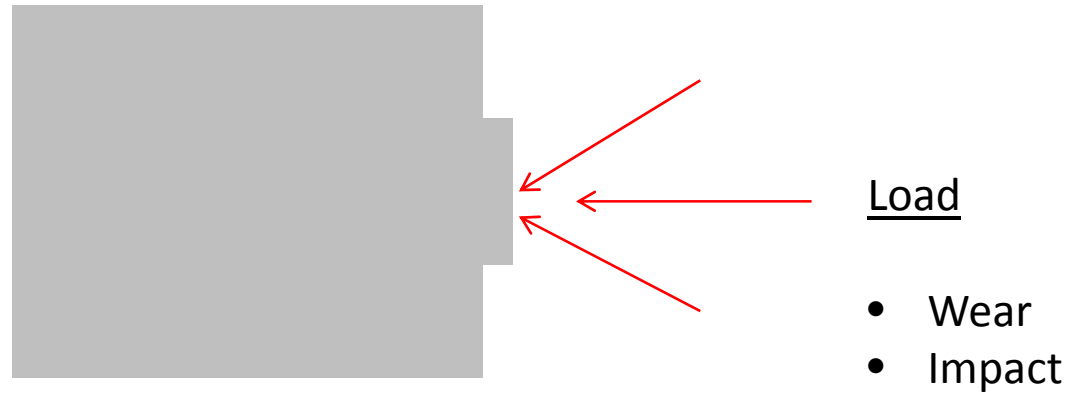
Conclusion

Main Subject:

- ✓ Reduction of production costs of parts
- ✓ Production capacity expansion

Sub-Purposes:

- ✓ Improvement of mechanical durability
- ✓ Weight reduction



Non-Ferrous Alloy

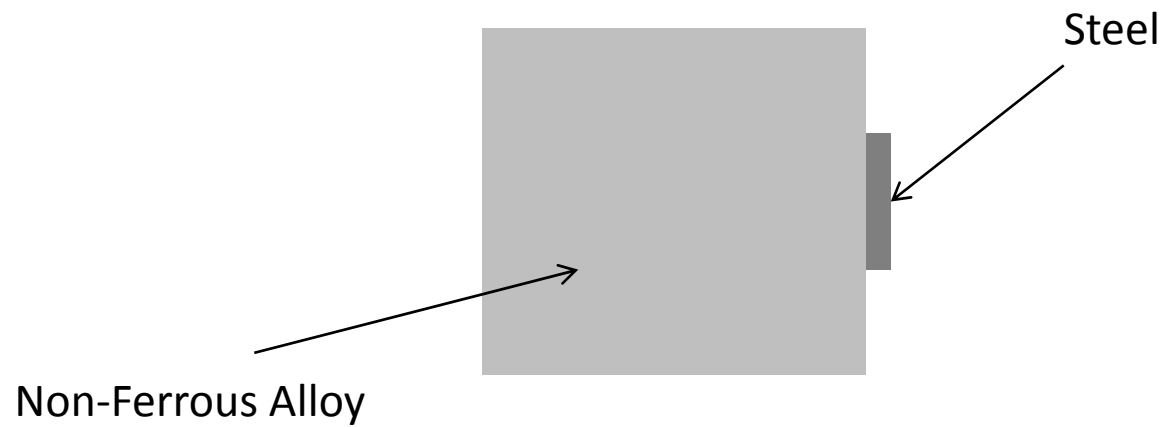


- + Light
- + Good Workability
- Low mechanical durability
- Poor wear resistance

Steel



- + High Strength
- + High wear resistance
- Costly machining
- Time consuming



- + Low Weight
- + Low Machining costs
- + Satisfactory Mechanical performance

Aim

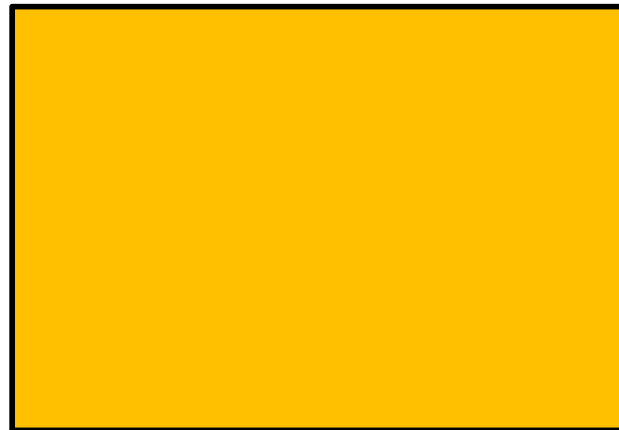
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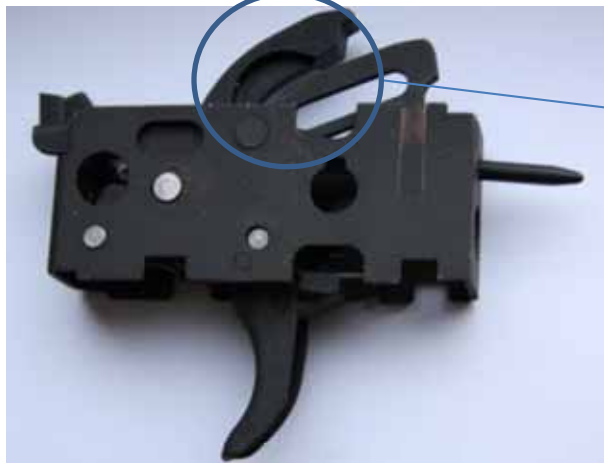
Conclusion

Insertion Casting





HK33



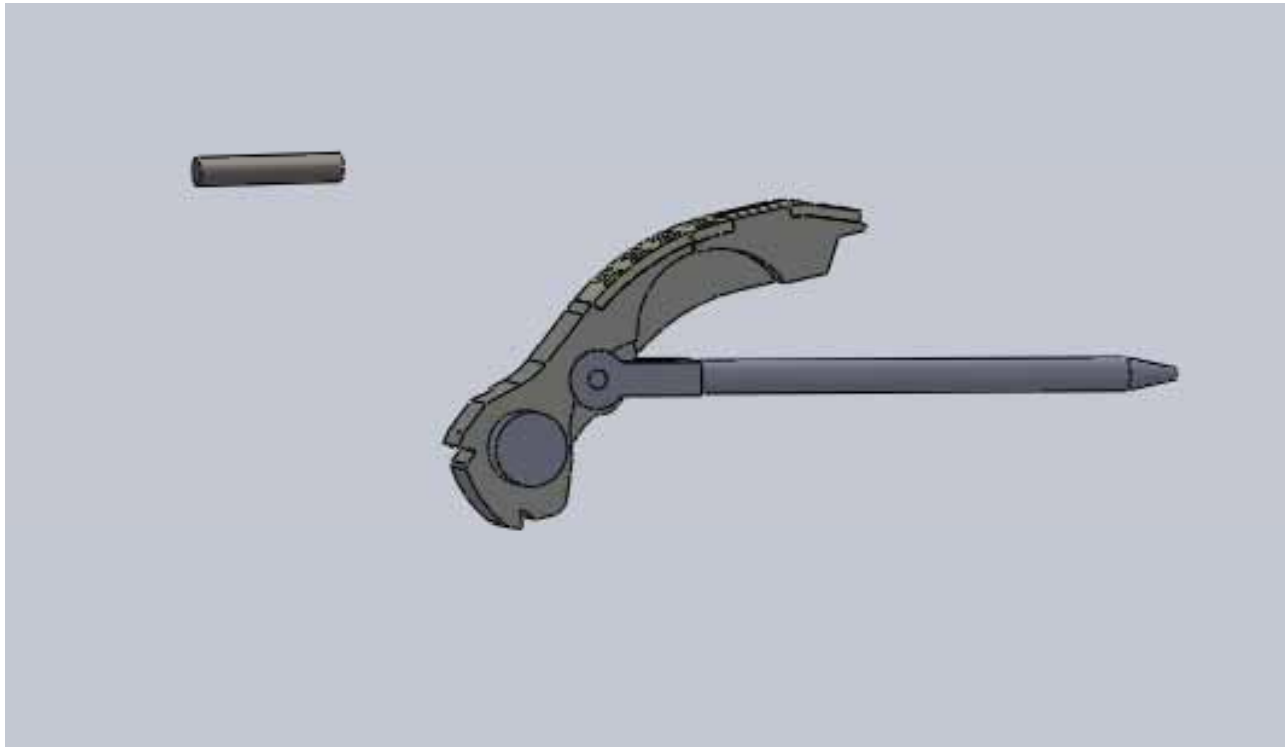
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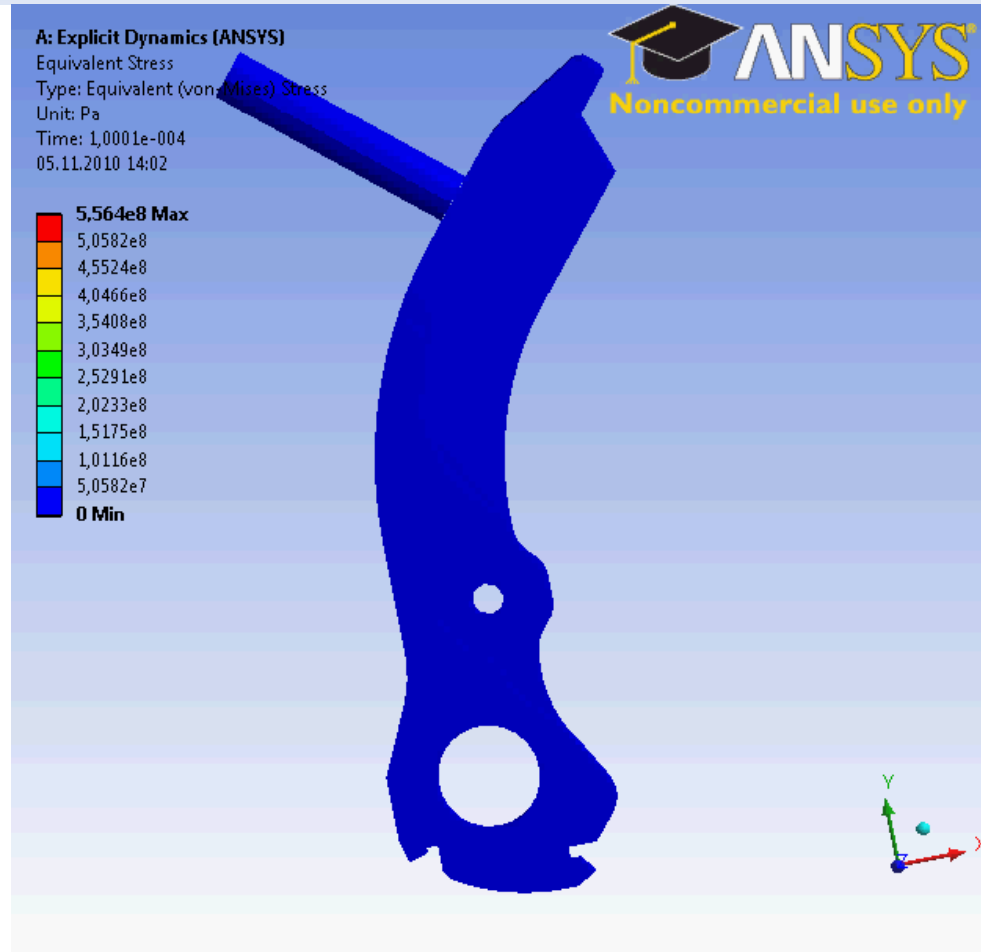
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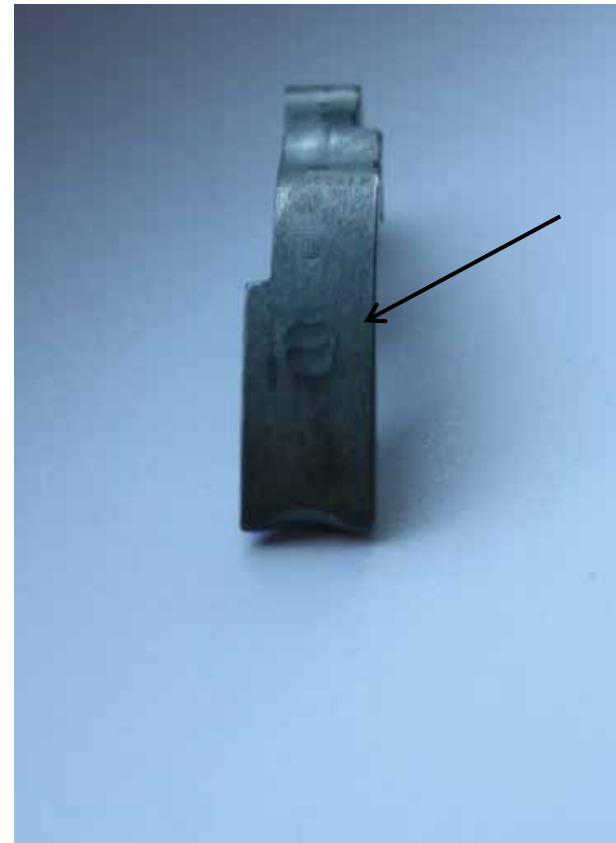
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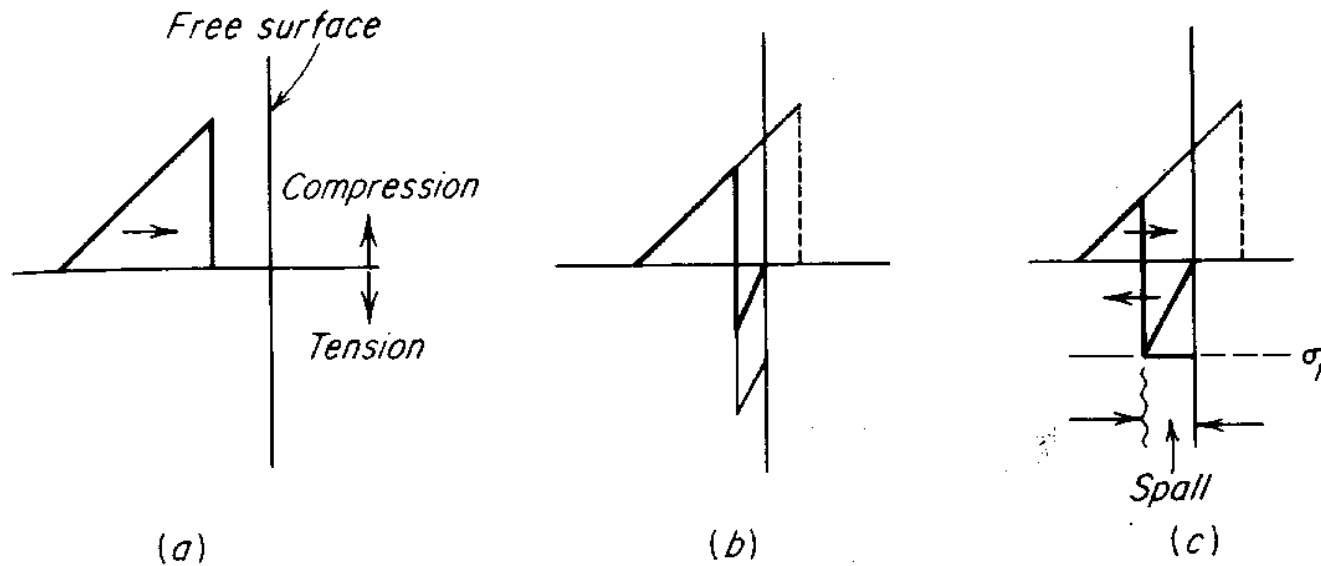
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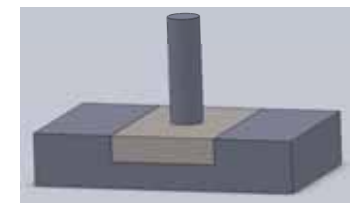
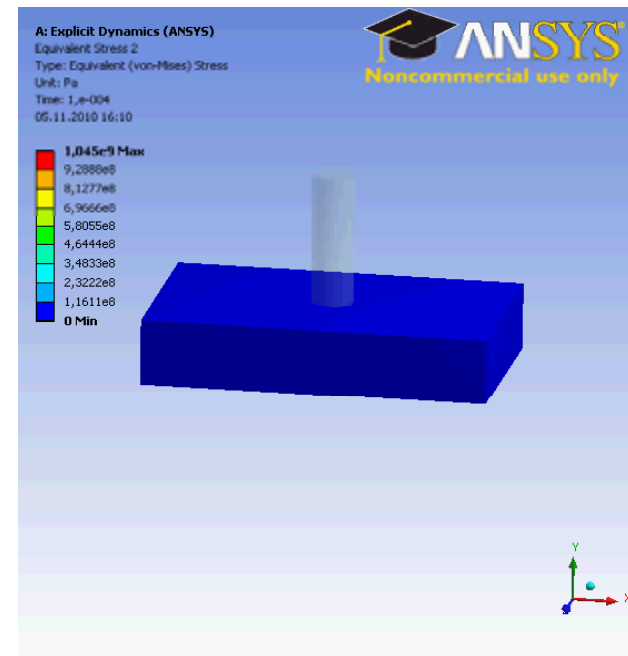
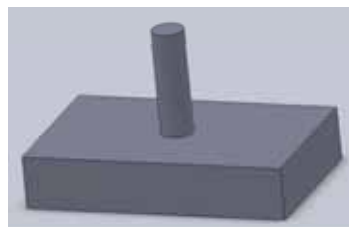
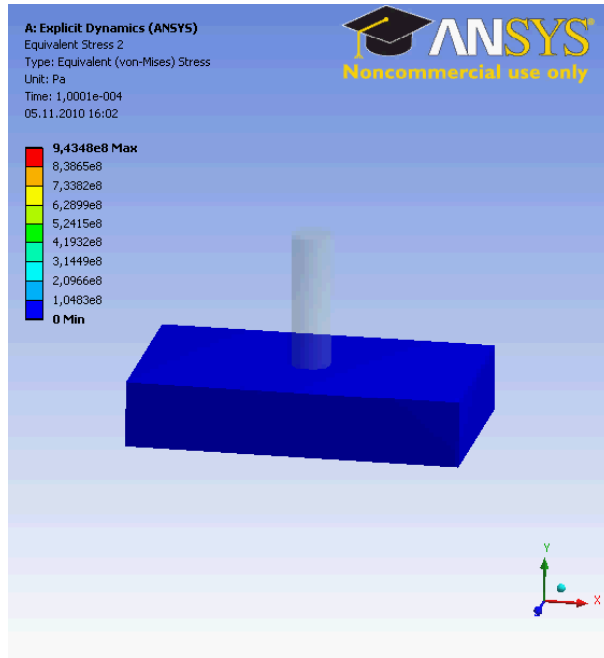


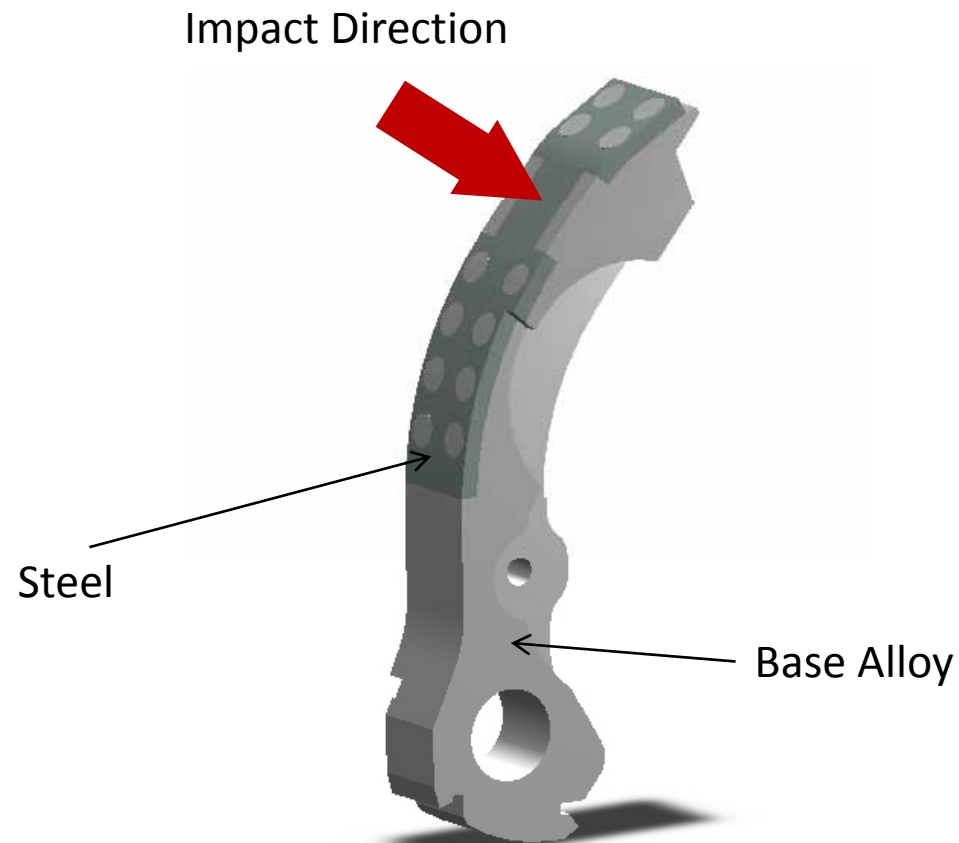




- a) Compressive shock wave approaching to surface
- b) Reflected with opposite sign (tensile)
- c) When reflected tensile shock wave reaches critical value fracture (spall) occurs

(J.L. O'Brein R. S. Davis, 1964)





Steel must satisfy:

- ✓ High strength
- ✓ Impact toughness
- ✓ Hardness (58-62 HRC) *

Base alloy must satisfy:

- ✓ Sufficient strength
- ✓ Required elasticity

Interface must satisfy:

- ✓ Sufficient Elasticity
- ✓ Lack of detrimental formations
- ✓ Perfect Wetting

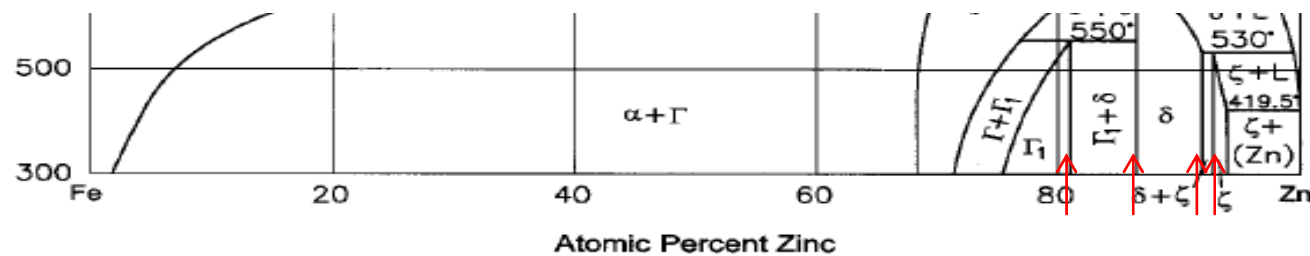


Material	B 390.0	ZA-27	ZAMAK 7
Yield Strength (MPa)	240	371	285
Ultimate Tensile Strength (Mpa)	280	426	285
Compressive Strength (Mpa)	368	359	414
Elongation (%)	1.0	2.5	14.0
Fatigue Strength (Mpa) ($5 \cdot 10^8$)	140	117	92
Charpy impact (J)	52	12-19	58-92*
Modulus of Elasticity (GPa)	81.2	77.9	75
Density (g/cc)	2.72	5.02	6.60
Melting Point (°C)	507-649	376-484	381-387

(ASM, 1997)

Fe-Zn phase	Micro hardness under 0.25 N (VHN)	Nano hardness under 10 mN (GPa)	Young's modulus (GPa)	Linear expansion coefficient (10^{-6}K^{-1})
Fe	150		210	11.30
δ^K	285	4.29	140	21.78
δ^P		3.45	134	
ζ	112	2.55	117	23
Zn	70		75	29.3

(G. Reumont, J.B. Vogta, A. Iosta, J. Focta, 2001)



(V. Raghavan, 2003)

According to Mita et al, During solidification of zinc some intermetallics may form at iron-zinc interface even without any aging or tempering processes.

Material	AISI 303*	AISI D-2 (DIN 1.2379)**	AISI S-7 ***
Yield Strength (MPa)	415	1570	1520
Ultimate Tensile Strength (Mpa)	690	1890	2050
Hardness (HRC)	19.0	59	55-58
Elongation (%)	40.0	-	10.0
Fatigue Strength (Mpa) ($5 \cdot 10^8$)	330	117	92
Charpy impact (J)	160	77	135
Modulus of Elasticity (GPa)	81.2	195	205

* Annealed and cold rolled, ** Air-quenched from 1030 °C tempered at 480 °C, *** Air-hardened from 955 °C and tempered at 200 °C

(ASM, 1997)

Die Cast Machine : Hidroteknik MEP-200



Die Cast Mold



Inserts



Aim

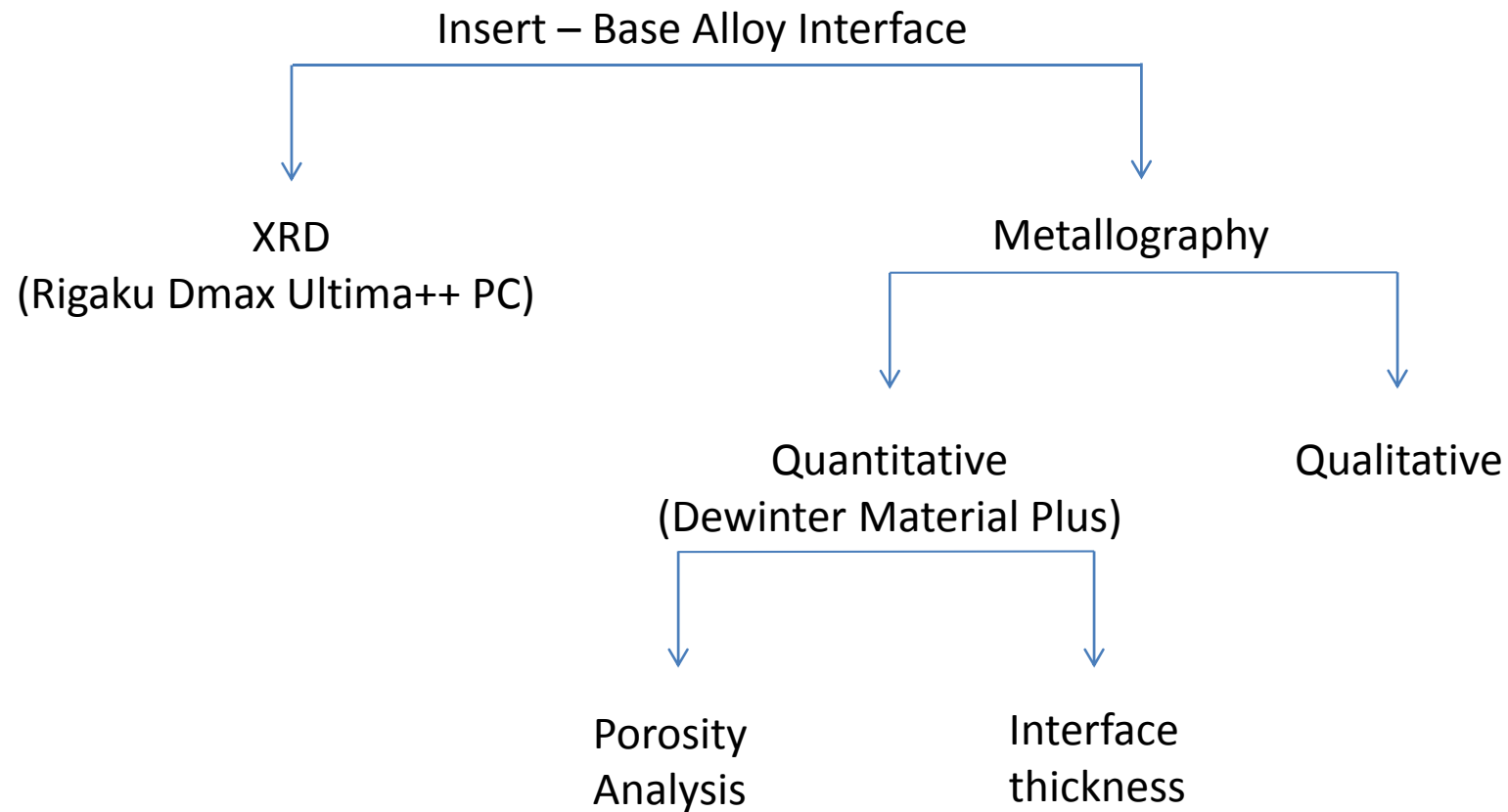
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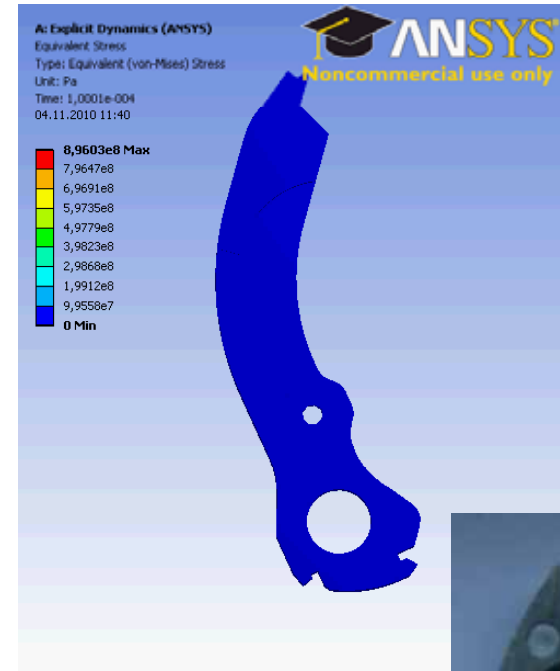
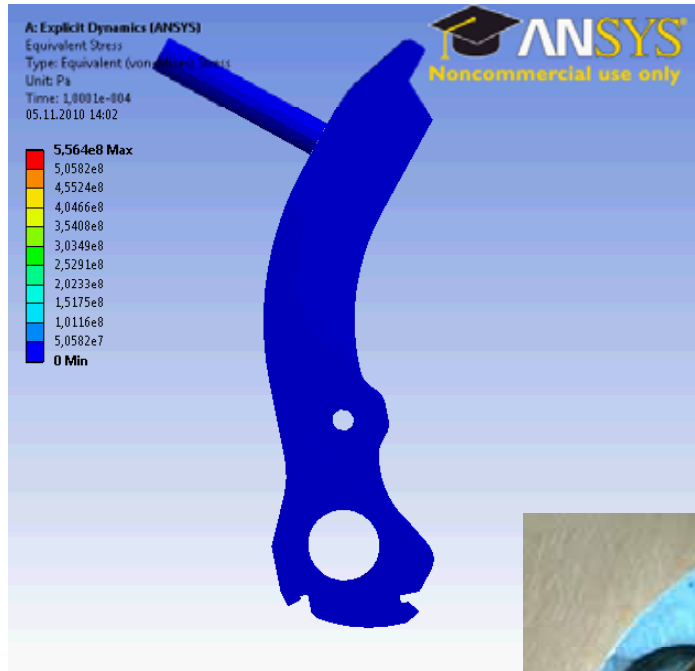
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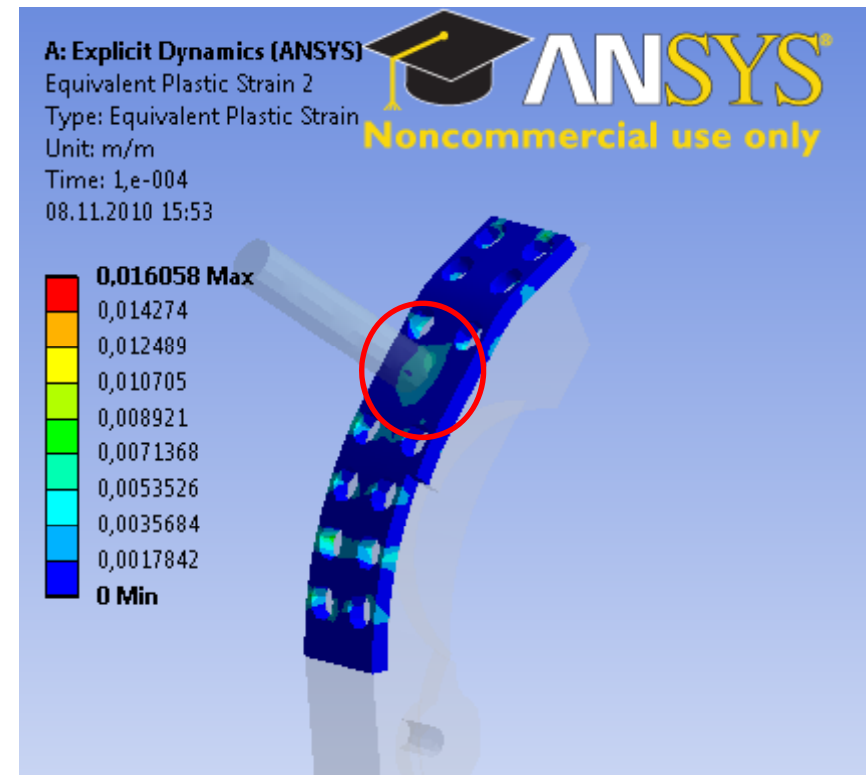
Conclusion





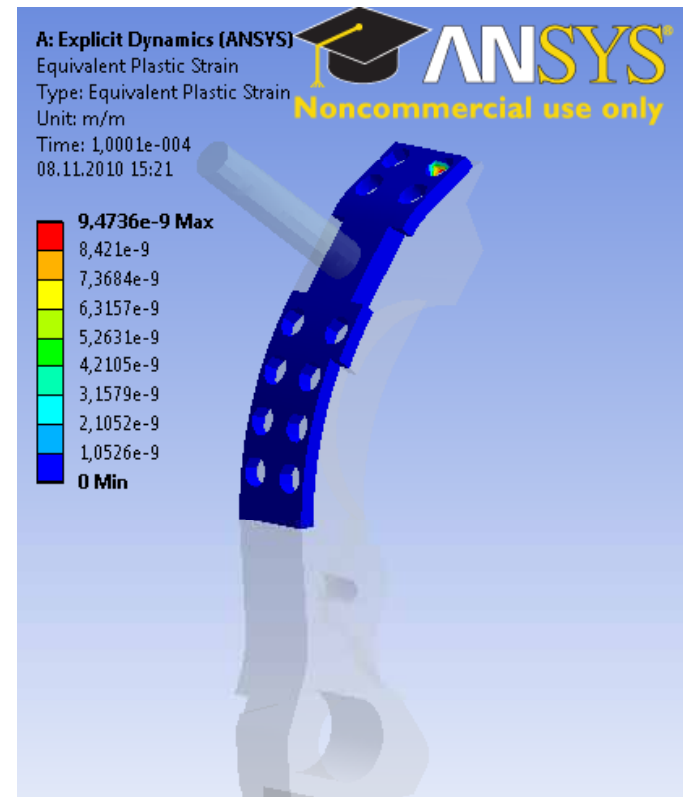


AISI 303 insert

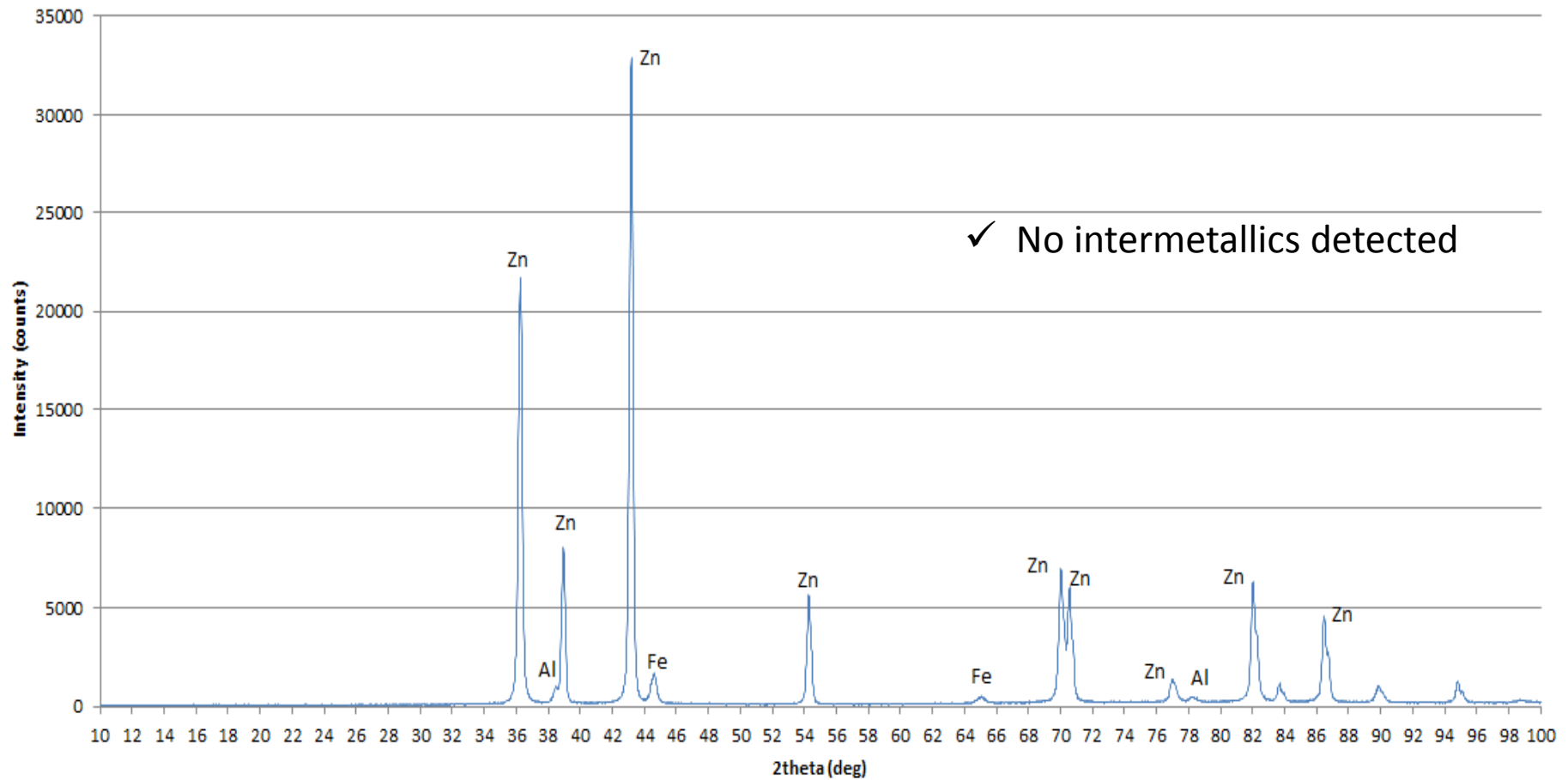


90 bullets fired in automatic mode, No visible fracture or crack initiation

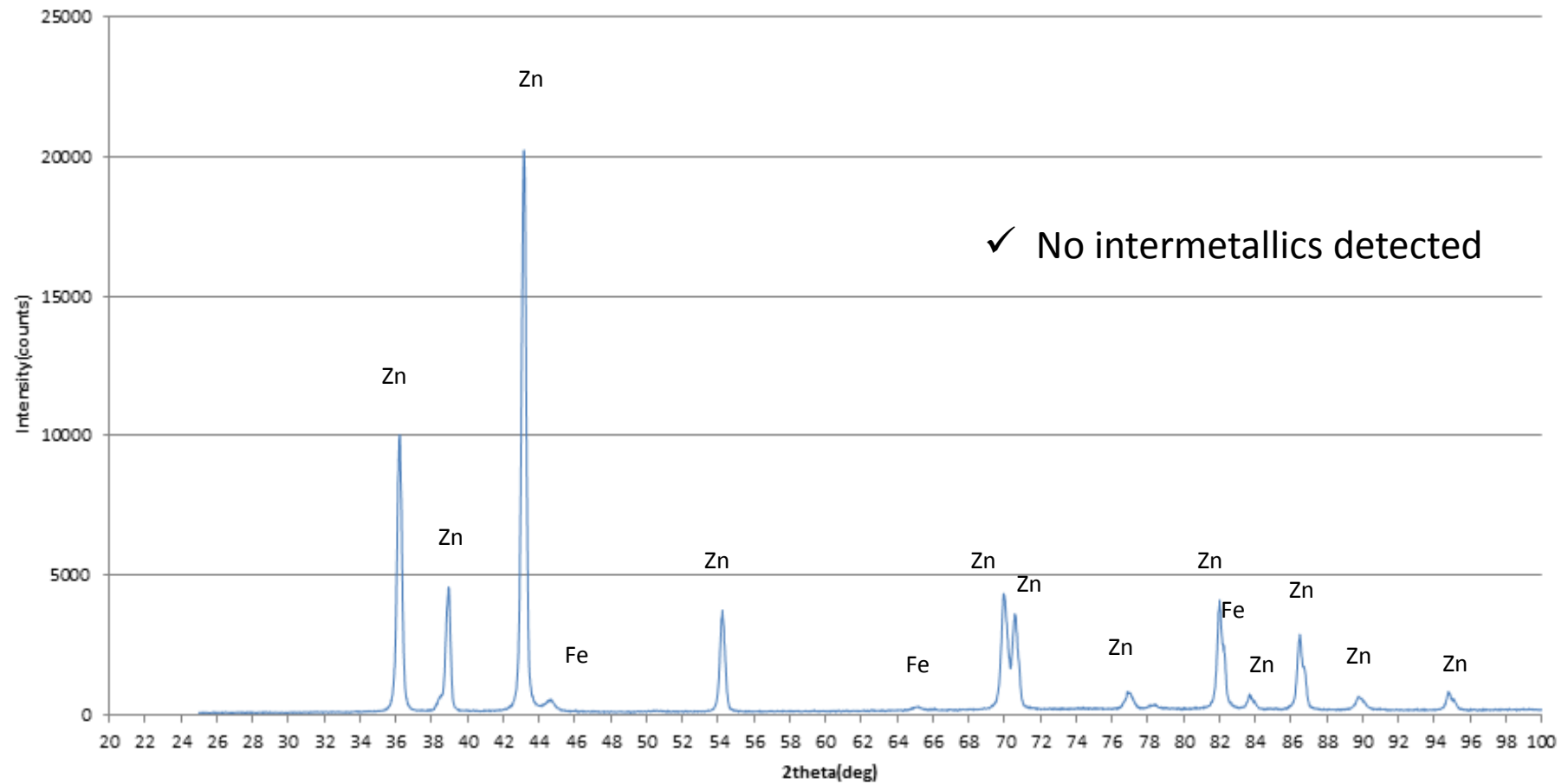
AISI D2 insert

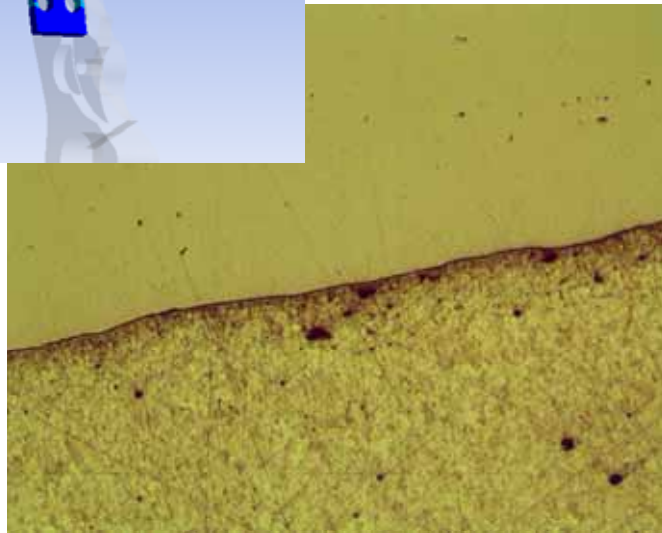
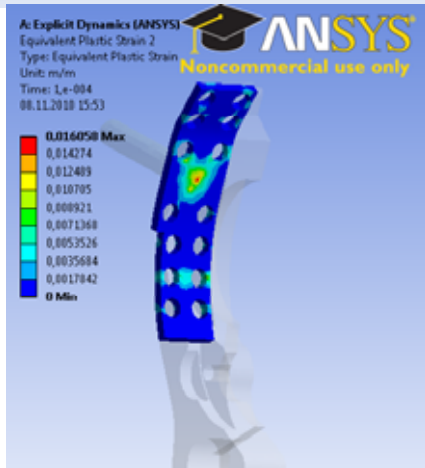


XRD Patterns of Zamak 7 – AISI 303 interface



XRD Patterns of Zamak 7 – AISI D2 interface

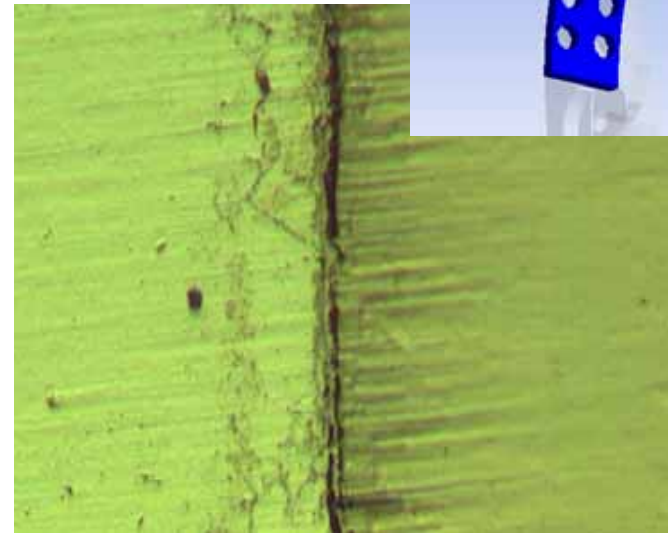
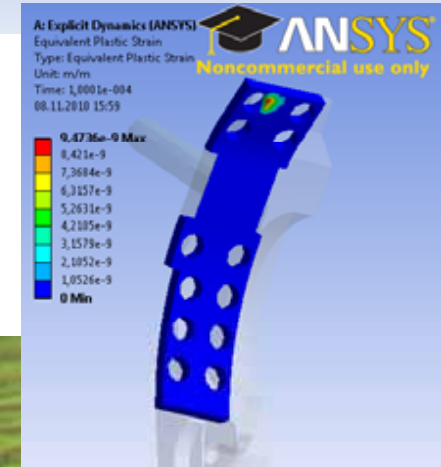




AISI 303 insert

Deformation at the interface

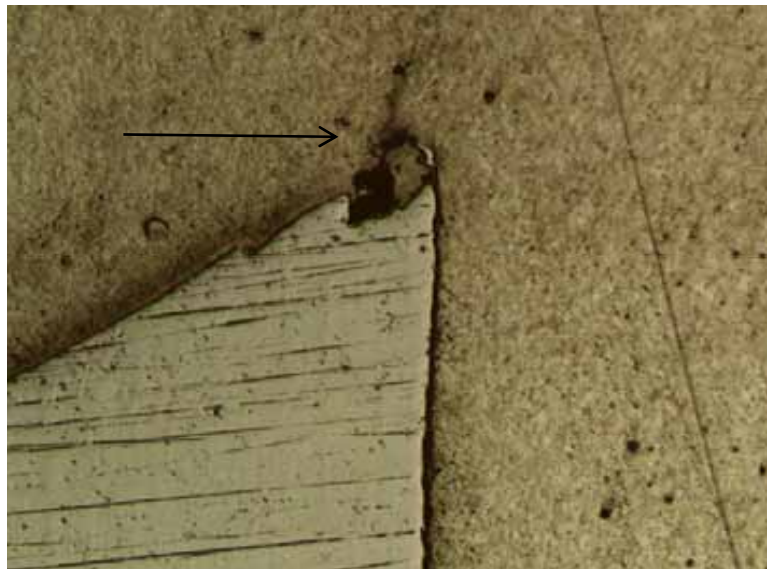
Qualitative analysis



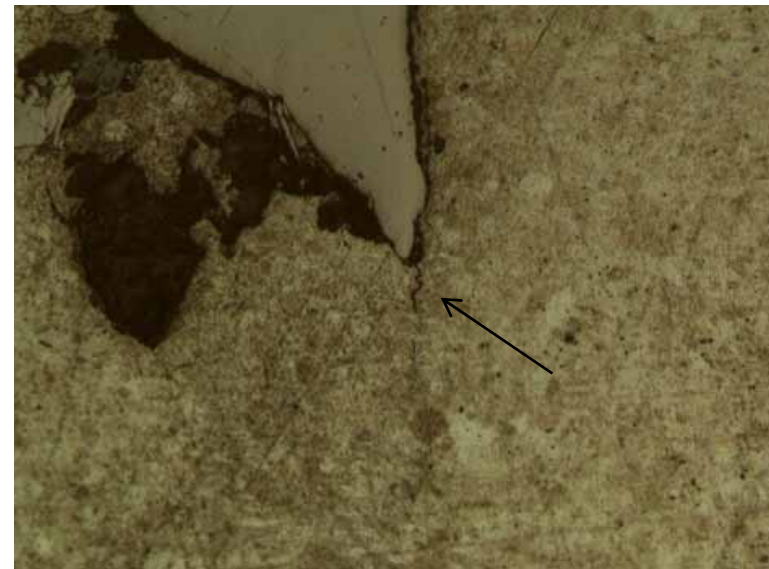
AISI D2 insert

No Deformation

Qualitative analysis



Porosity formation at broken sharp corner



Crack propagation in front of a corner

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NovaFlow & Solid CV 4.0r4
mkekalip1.00.psp
Date          2010. 11. 08
YZ plane, mm  248.00 [124]

Box dimension, casting position and number of cells
along X, mm   246.00000  123.03150  125
along Y, mm   80.00000   39.74917   42
along Z, mm   322.00000  161.27060  163

Minimal mould thickness, mm  25.00000
Size of cells, mm           2.00000
Total cells:                 792 120
Casting cells:               22 311

Boundary conditions
Low                           High
YZ plane                      Normal conditions
XZ plane                      Normal conditions
XY plane                      Normal conditions

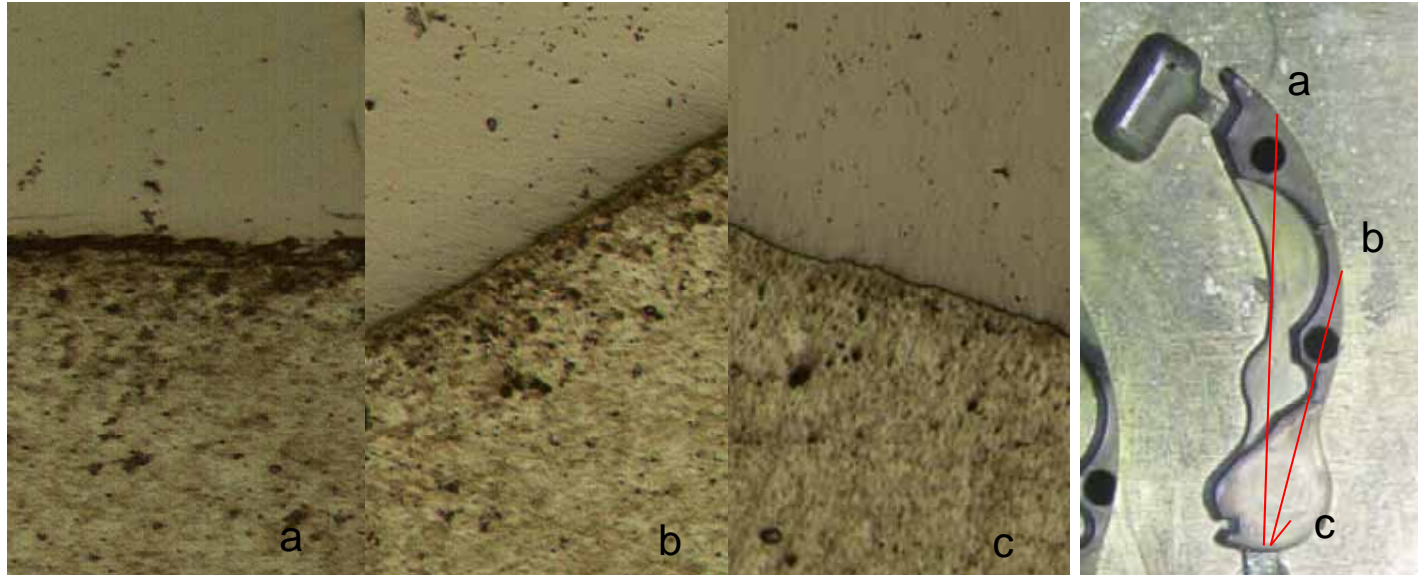
0 - quasi-equilibrium model calculation, without segregation
Without convection
Consider sticking

Mould materials               T, °C
356                          720.0
AISI H11 / H13                220.0
Air_in mold                   220.0
Water                         220.0
Medium_Air_in mold            20.0

NovaCast AB
Copyright 1996 -2009

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Quantitative Porosity Analysis

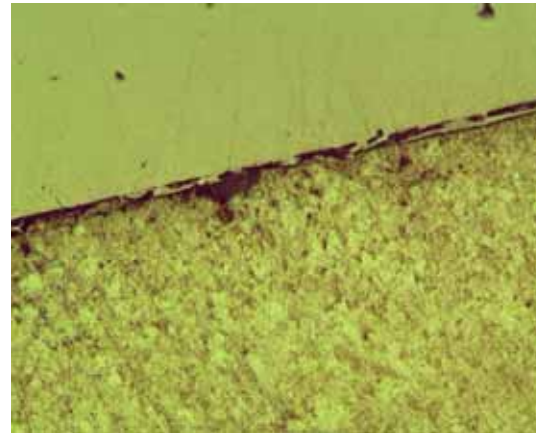


	Distance from the gate (mm)	Porosity (%)
a	58.6	3.9
b	37.8	2.5
c	4.9	1.9

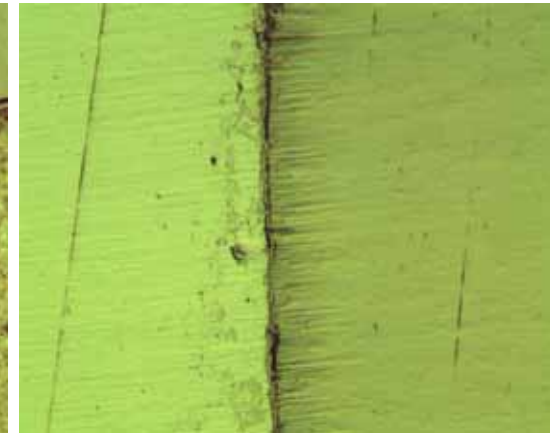
Quantitative Interface Analysis



As-casted ZAMAK7-303
1.18%



Operated ZAMAK7-303
2.03%



Operated ZAMAK7-D2
1.32%

- ✓ Designed process remarkably reduced production time and eliminate all machining processes.
- ✓ Inserts limited high amount of shockwaves in itself, therefore stress distributed along the parts are reduced. This fact increases factor of safety and protect from the fatigue failure.

- ✓ Parts with AISI D2 inserts satisfied all mechanical requirements. After the tests, no plastic deformation at the impact point or interface as it is expected by simulations.
- ✓ AISI 303 stainless steel has insufficient hardness for high speed impact loadings

- ✓ No intermetallics are formed during the process. High Cr content may help to prevent these interactions.
- ✓ Sharp insert corners should be strictly avoided to prevent porosity formation and micro-crack initiations.
- ✓ Die design should be made in the way that inserts must be close to gates in order to reduce porosity at the insert-base metal interface.

Thank you for your interest...

Writers specially thank to:



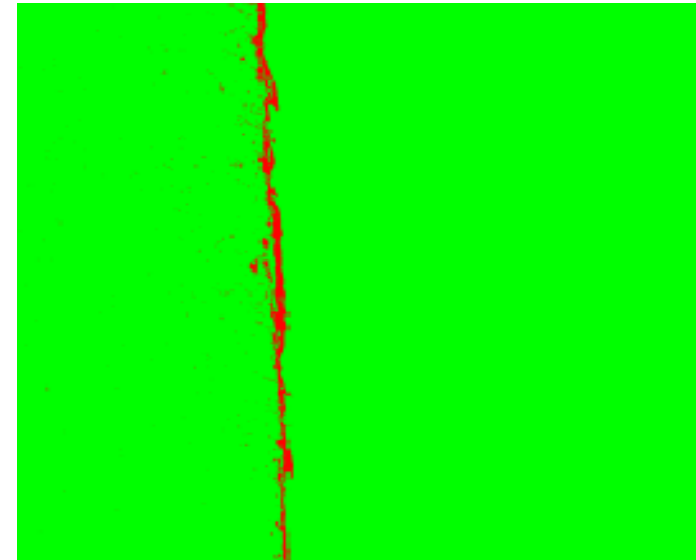
RUTAŞ Die Casting
Co. Ltd.



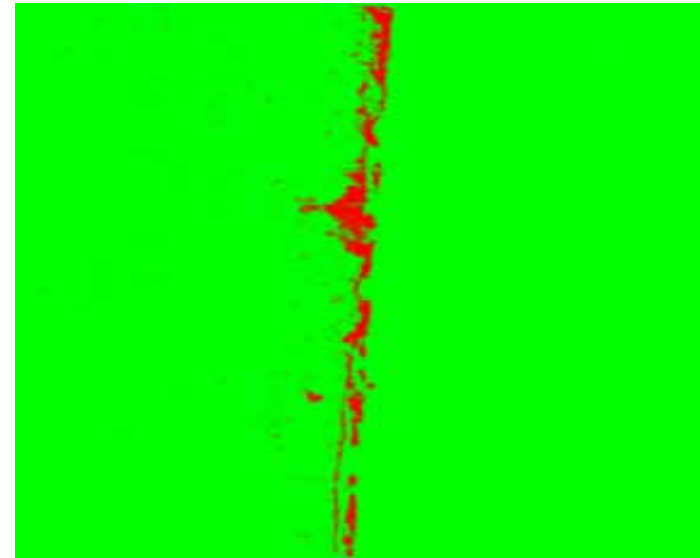
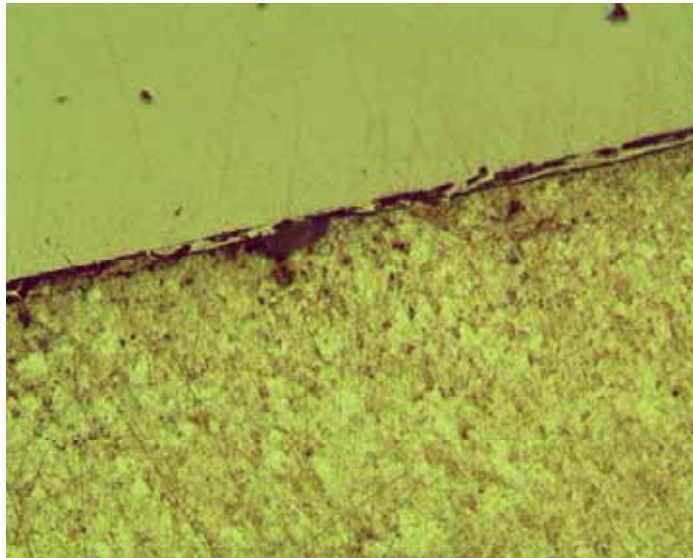
Republic of Turkey
Ministry of Industry
and Trade



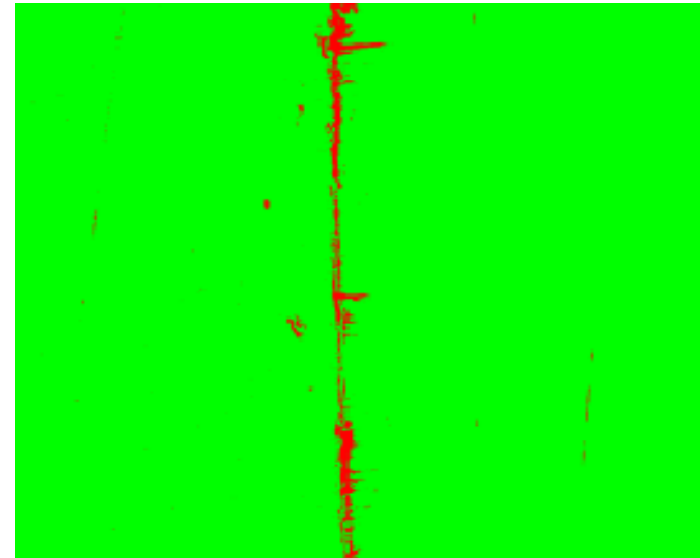
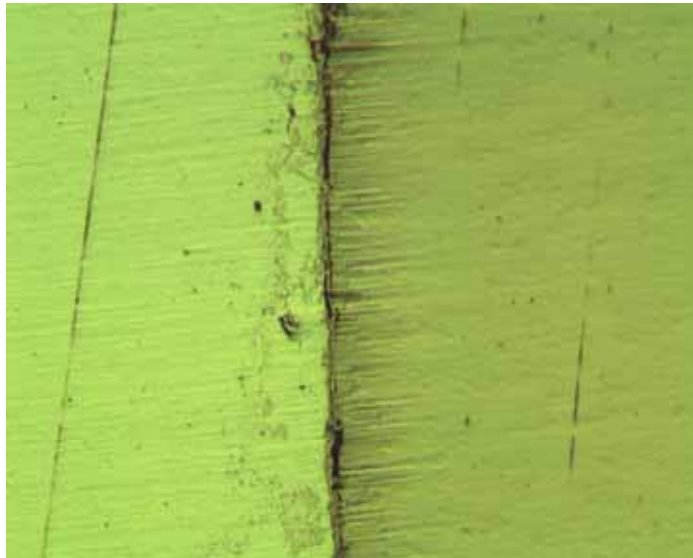
Mechanical and Chemical
Industry Co.



As-casted ZAMAK7-303
1.18%



Operated ZAMAK7-303
2.03%



Operated ZAMAK7-D2
1.32%

