An Improvement of Weld Line Mechanical Strength for the Injection Molding

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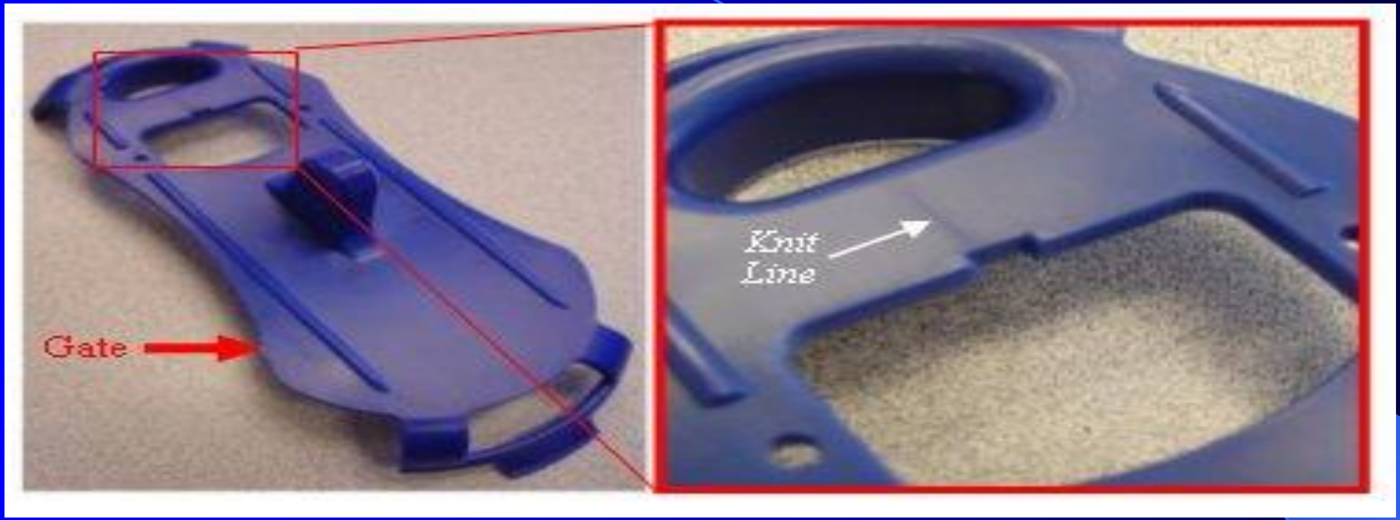
Outline

- Introduction
- Ejector Pin Compression System
- Experimental Setup
- Results and discussion
- Conclusions

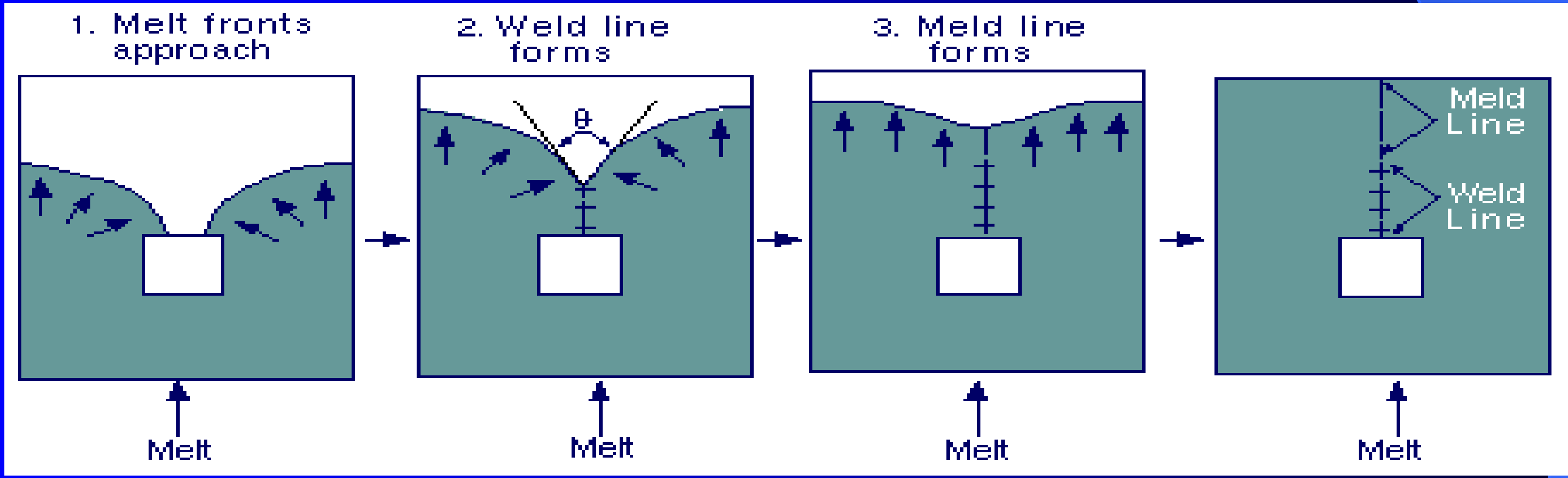
The Defects of Weld lines

- Weld lines occur wherever two or more melt fronts meet during filling stage when parts have shut-off areas or molded with multi-gates.
- Weld lines are often visible on an injection-molded part and reduce their mechanical strength.

Weld Lines Occur When Parts with Shut-off Areas

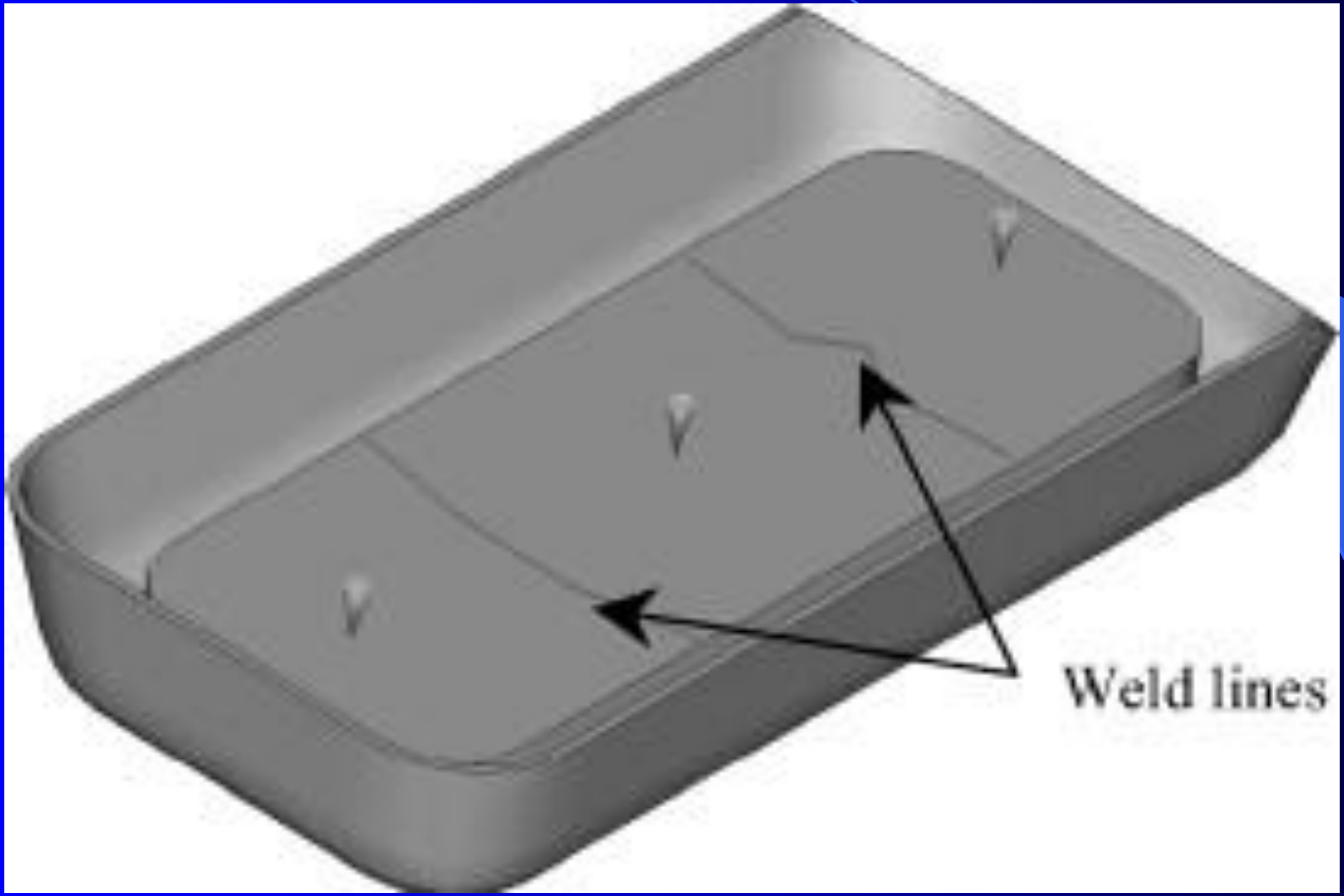


http://www.protomold.com/Design_Tips/UnitedStates/2004/2004-08_designtips/



http://www.dc.engr.scu.edu/cmdoc/dg_doc/develop/trouble/weldmeld

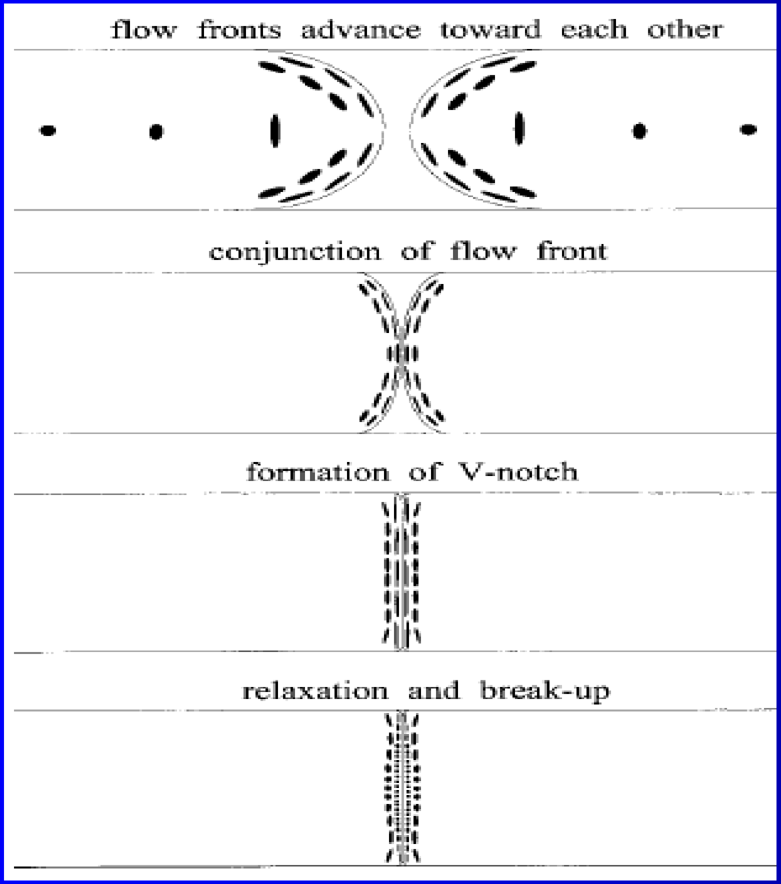
Weld Lines Occur When Parts Molded with multi-gates

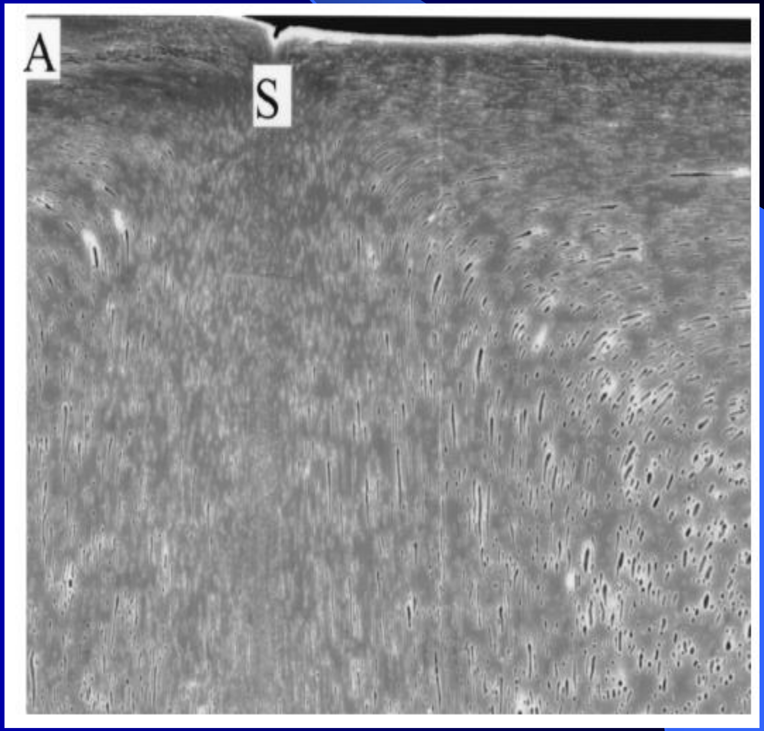


R. Spina 2004

Weld Line Defects

- The weld line defects are due to the behaviours of fountain flow to generate poor intermoleculer entangling forces and parallel molecular orientation across weld lines (Y. Kobayashi, G. Teramoto, T. Kana 2011)





YOUNGGON SON, KYUNG HYUN AHN, *and* KOOKHEON CHAR 2001

How to Reduce the Influence of Weld Lines

- Weld lines are hard to be avoided completely especially for parts with shut-off area or molded with multi-gates.,

1. higher mold temp., melt temp., packing pressure, and injection speed
   - to increase the weld line intermoleculer entangling forces
2. adjust parts geometry, gates location, and injection molding parameters
   - to control the locations of weld line
3. dynamic mold surface temperature control systems and cavity surface coating methods
   - to increase the temperature of melt front merging
4. sequential-valve-gate molding
   - to control the locations of weld lines

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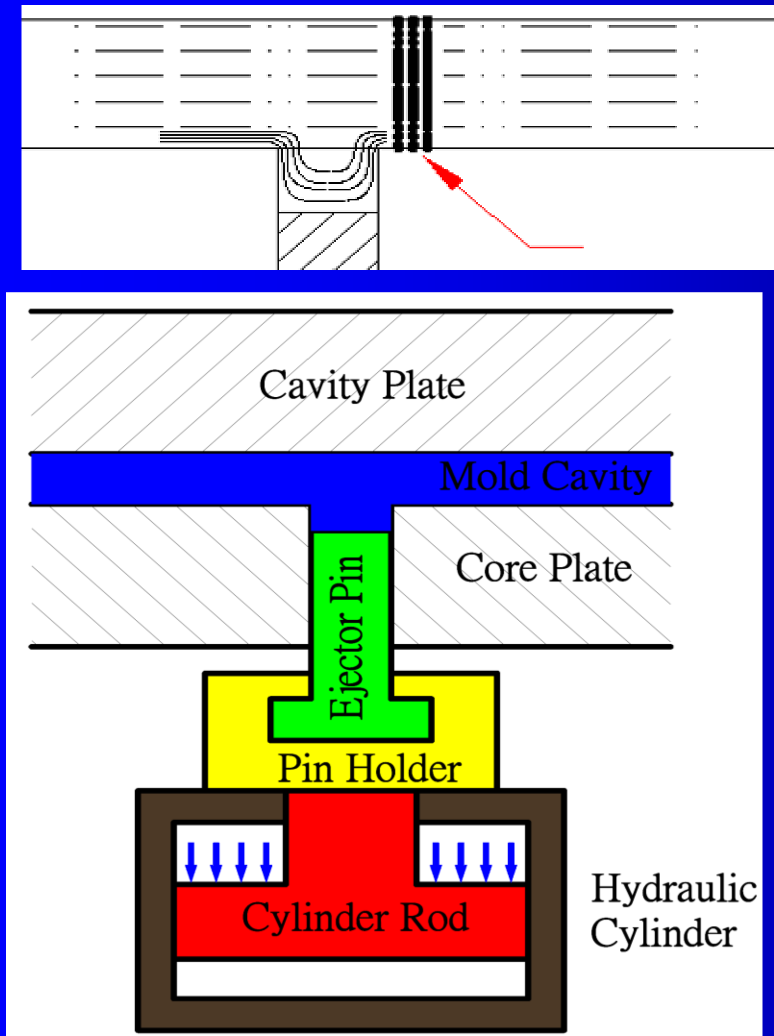
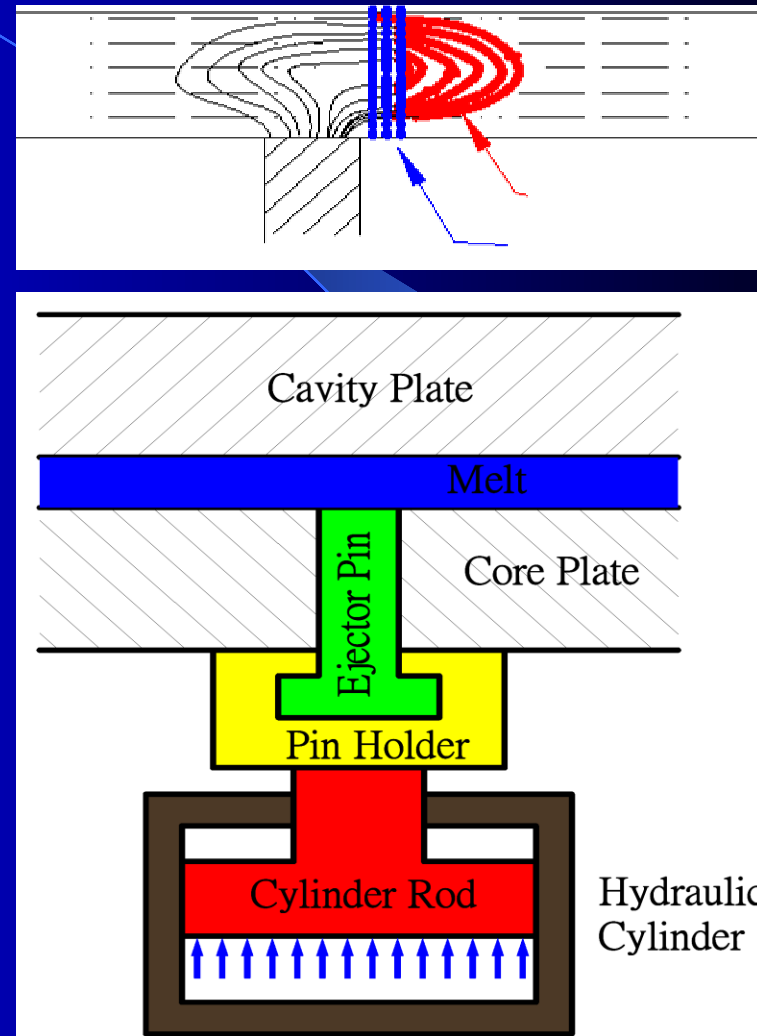
Ejector Pin Compression System



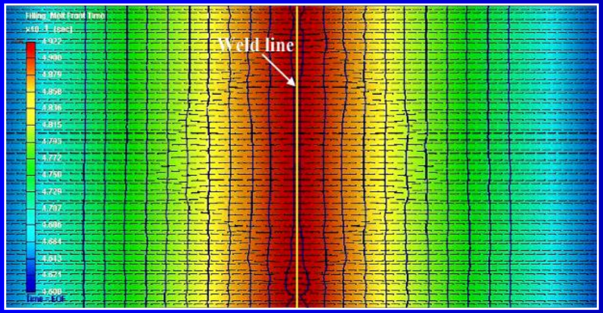
(a) Ejector pins are drawn back

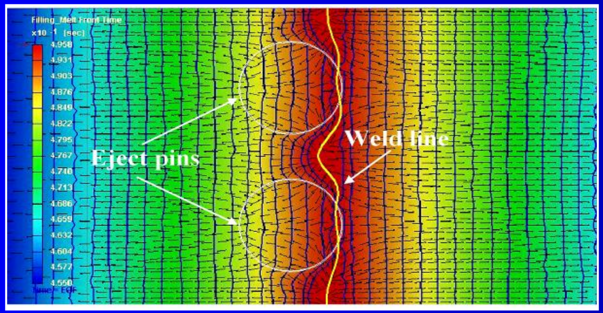


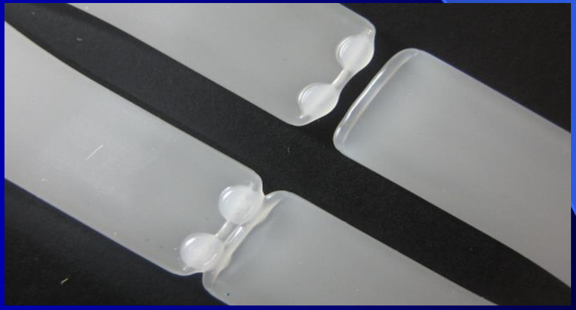
(b) Ejector pins are pushed to compress the resins

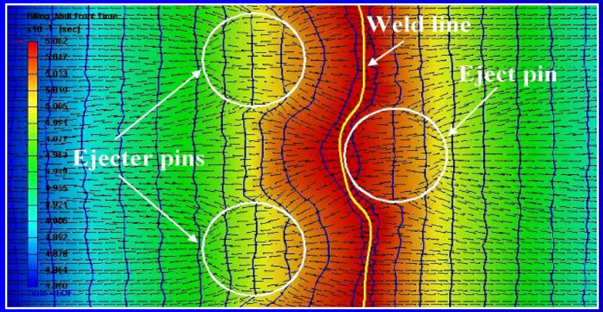
Analysis of CAE Simulation
(Moldex3D R9.1)

➢ to determine ideal diameter and position of ejector pins

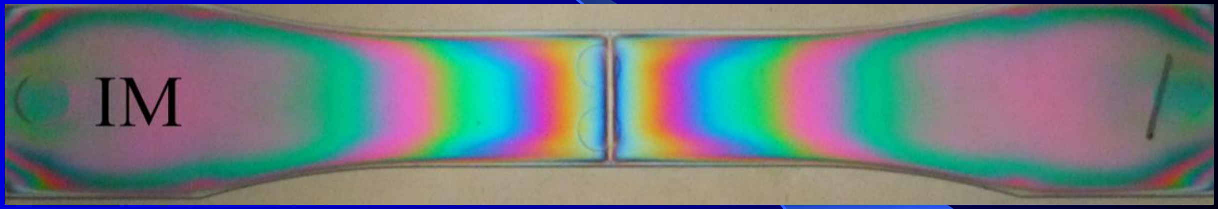


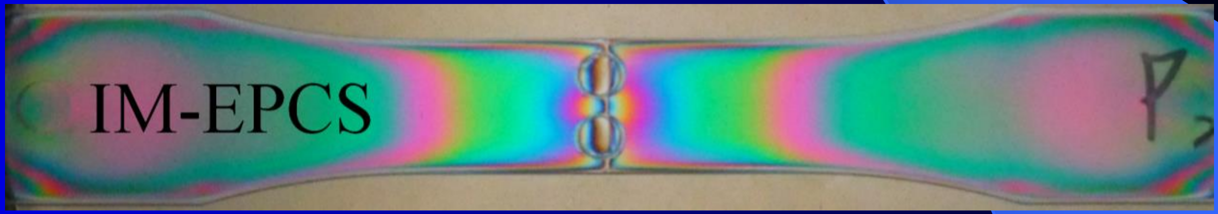


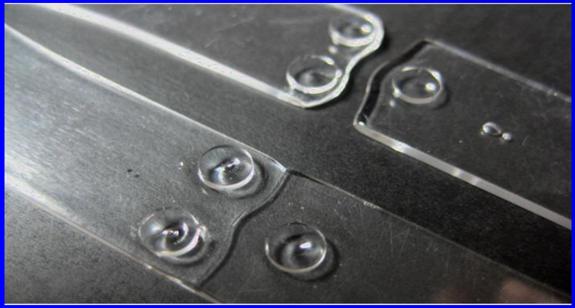


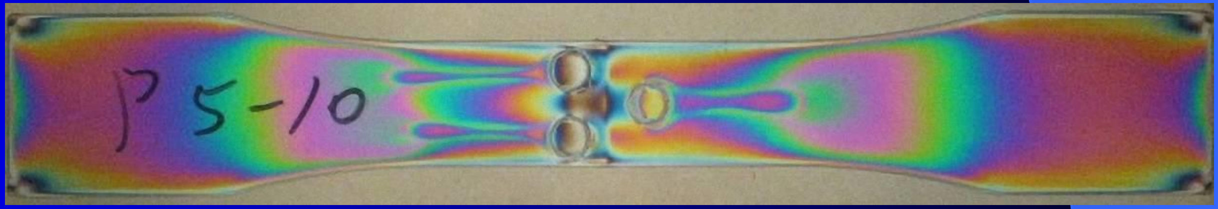


The Birefringence of Specimens Made of PS Resin









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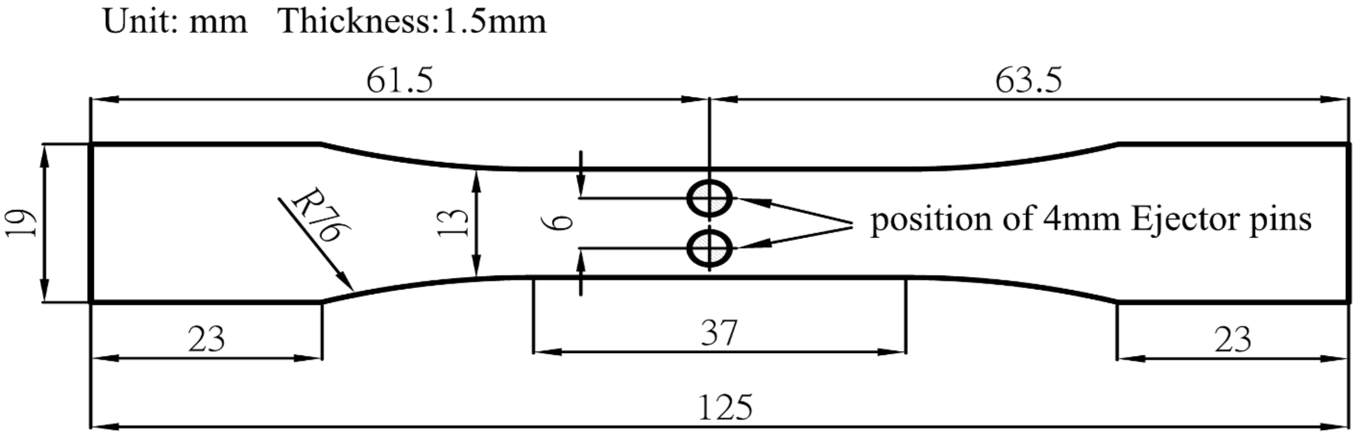
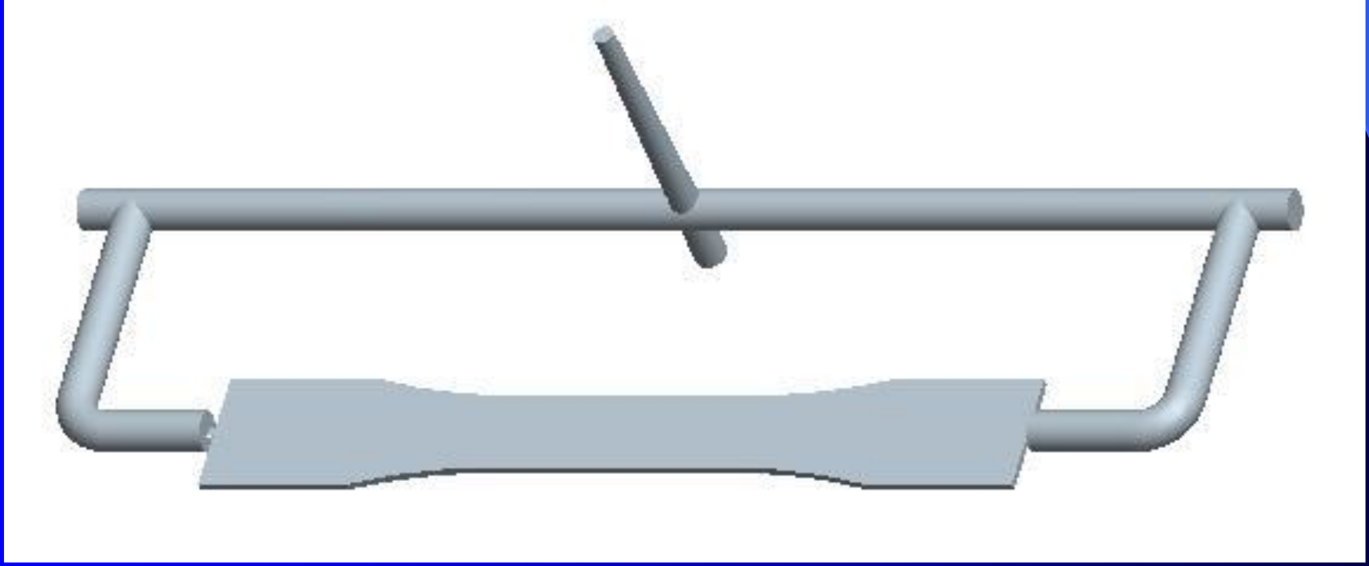
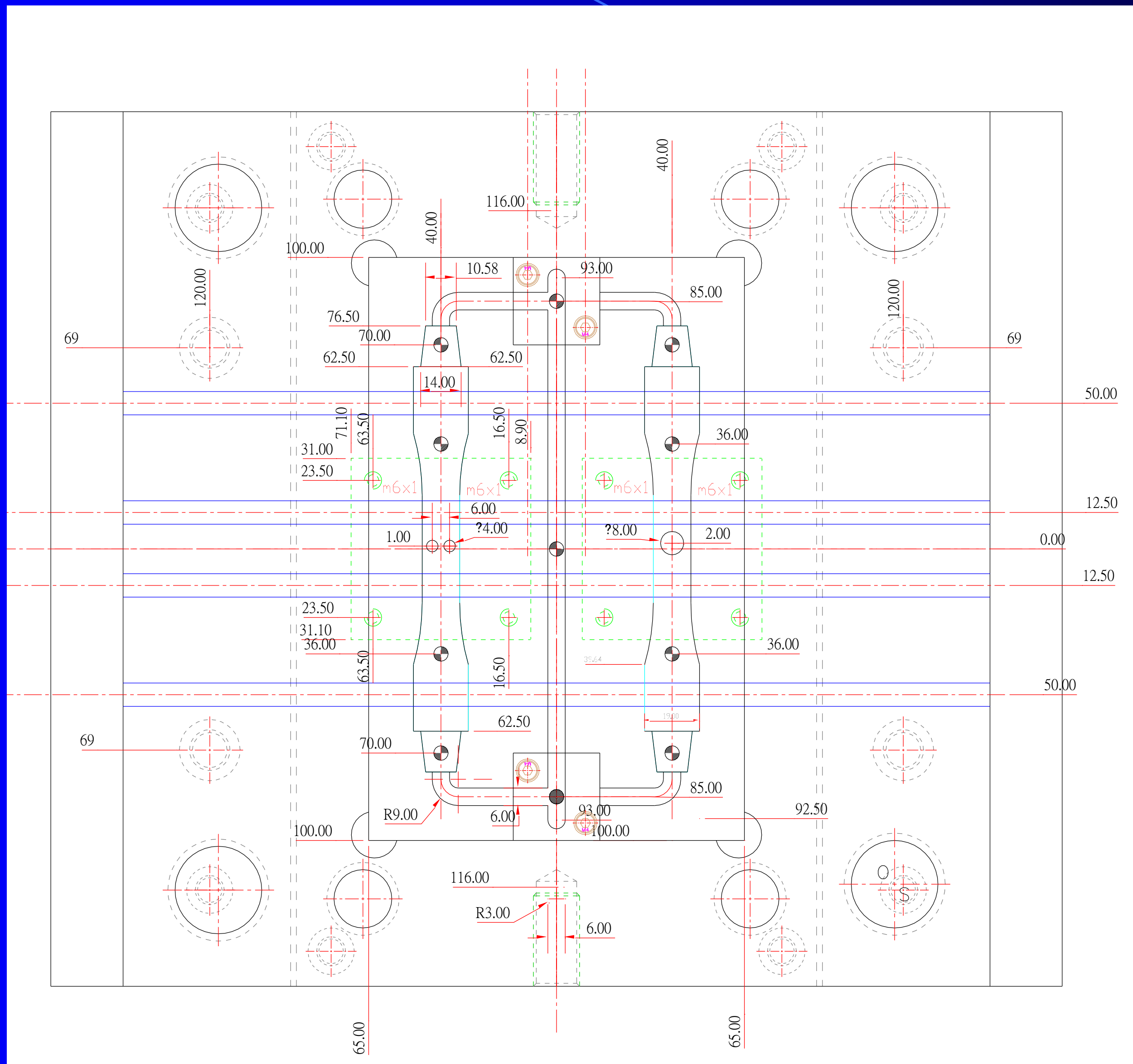
Geometry of Specimen





Mold Design


116.00
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85.00
R9.00
6.00
93.00
92.50
100.00
100.00
116.00
R3.00
6.00
65.00
65.00

Injection Machine

➢HE-50, Fu Chun Shin, Taiwan

TABLE I

Main items	Unit	Value
Screw diameter	mm	22
Maximal injection pressure	kgf/cm^2	2,224
Theoretical shot volume	cm^3	42
Maximal shot weight (PS)	gram	38
Maximal injection speed	mm/sec	300
Maximal injection stroke	mm	110
Clamping force	Tonf	50

Materials

- To verify the feasibility of the EPCS, three different types of polymer are adapted in this study.

(1) Polystyrene (PS) characterized with hard and brittle properties (525N, Kaofulex, Taiwan)

(2) Polypropylene (PP) characterized with flexible property (Yungsox 3204, Formosa, Taiwan)

(3) Acrylonitrile Butadiene Styrene (ABS) characterized of high impact resistance property (PA756, Chiemi, Taiwan).

Process Parameters Setting

Process parameter settings	PS	PP	ABS
Melt temperature (℃)	210	230	230
Mold temperature (℃)	40	40	40
Injection speed (mm/s)	40	40	50
Packing pressure (Low) (Bar)	250	250	250
Packing time (Low) (sec)	1	1	1
Packing pressure (High) (Bar)	400	400	450
Packing time (High) (sec)	5	7	6
Cooling time (sec)	40	40	40

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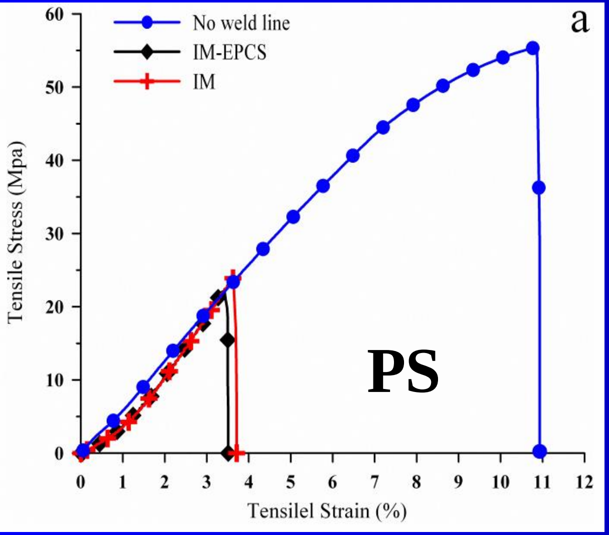
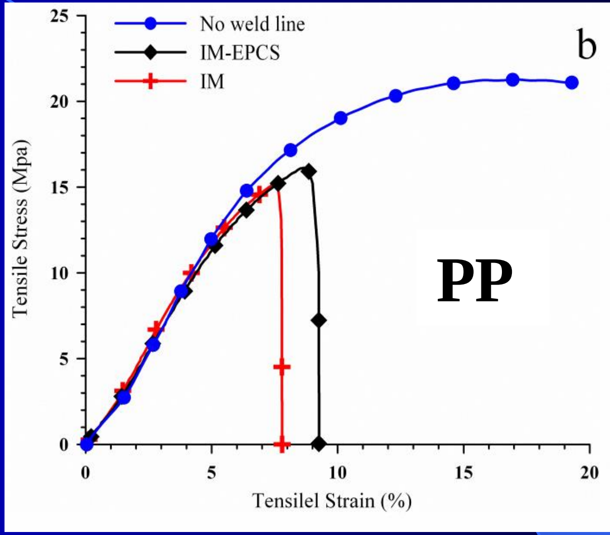
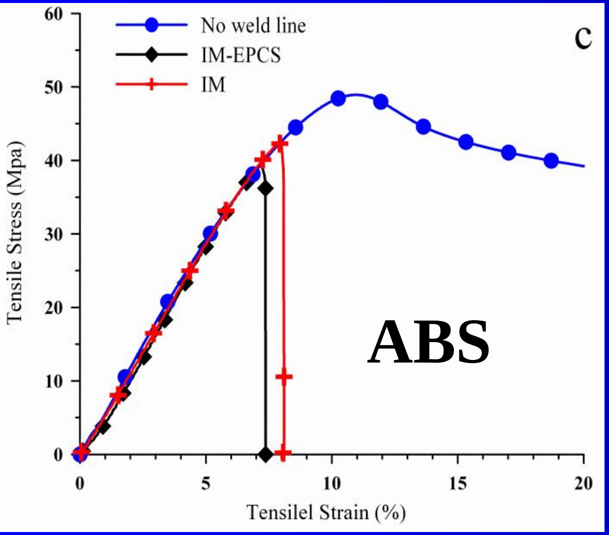
Tensile Properties

- stress versus tensile strain for various plastic materials



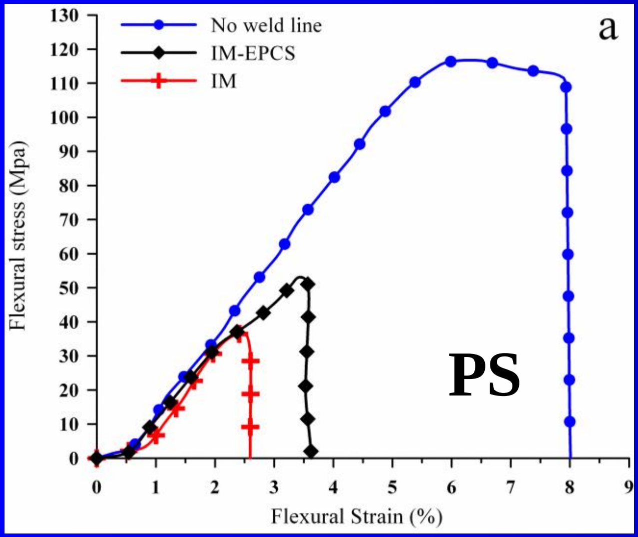


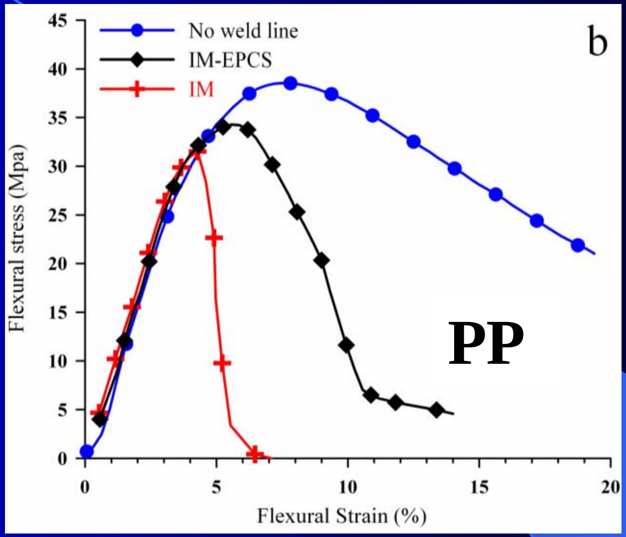


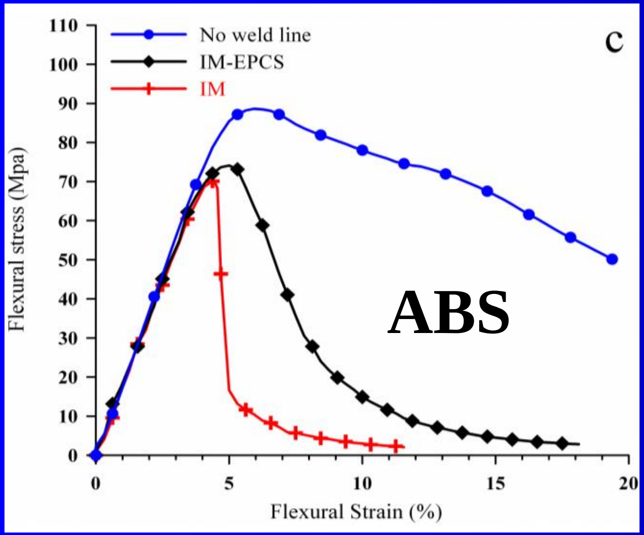
- EPCS just had limited effect to the maximal tensile stress and tensile strain.
- IM-EPCS slightly increase the tensile strength made of PP that belongs to flexible material.
- IM-EPCS slightly decrease the tensile strength made of ABS and PS.

Flexural Properties

- flexural stress versus flexural strain for various resins

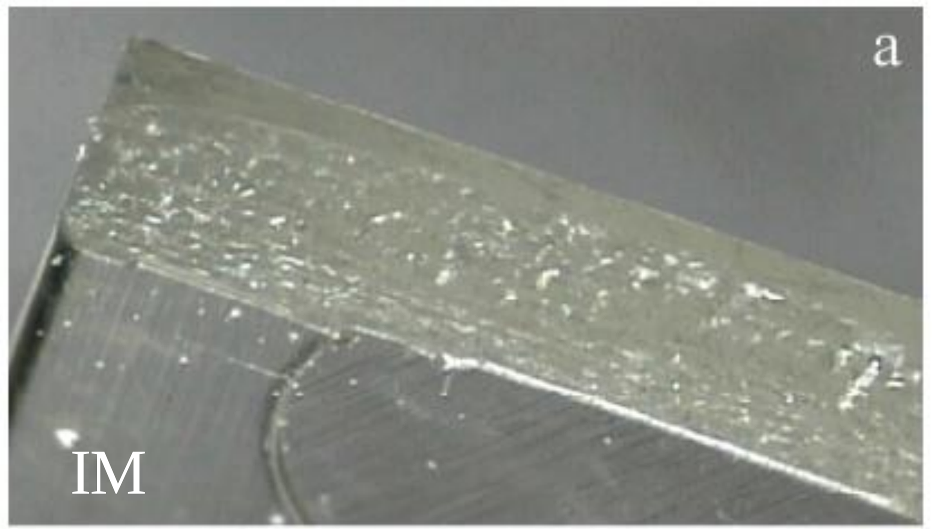


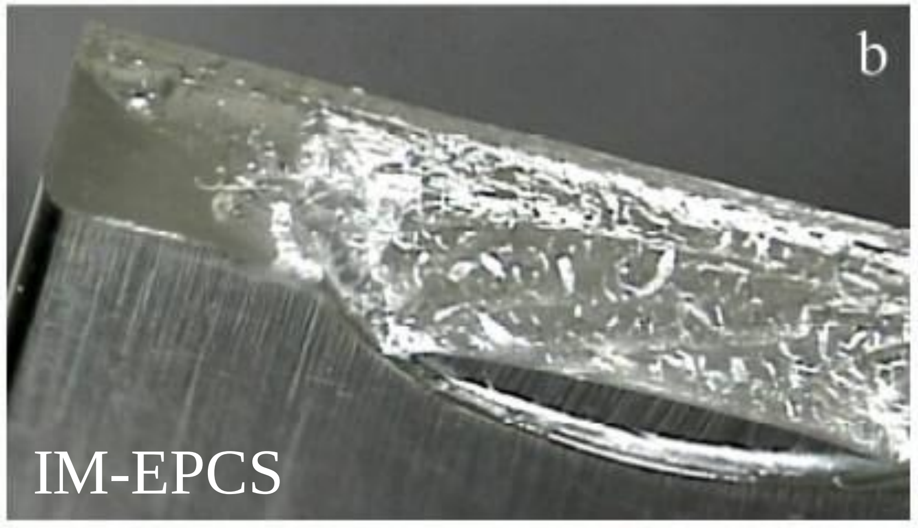




- The usage of EPCS can improve the weld lines maximum flexural stress and flexural strain in all of the experimental materials.

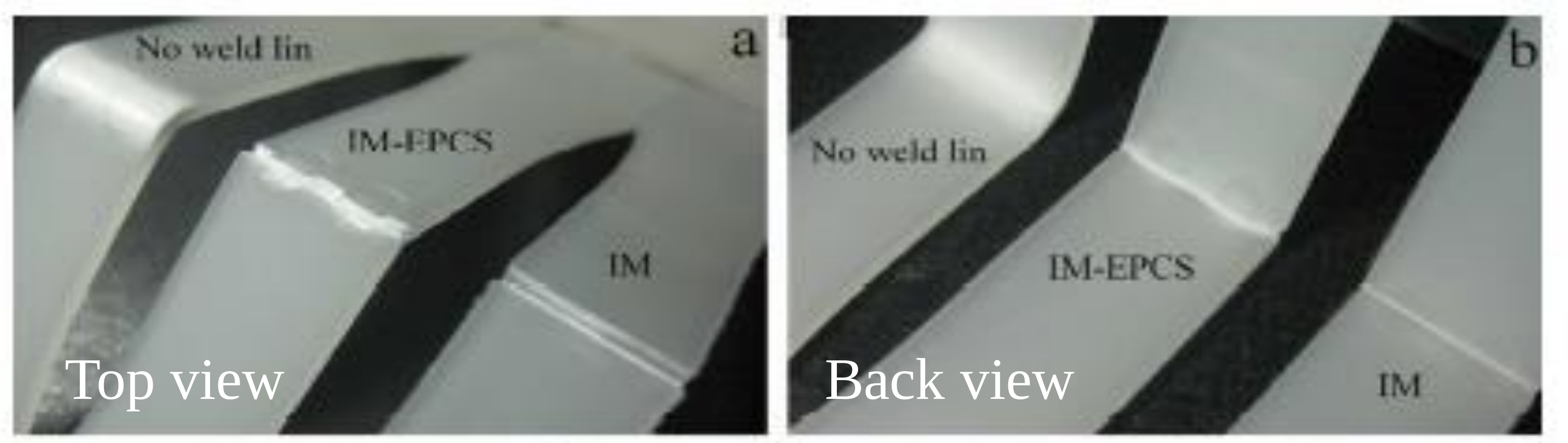
The Cross Sections of PS Specimens Along Weld Lines





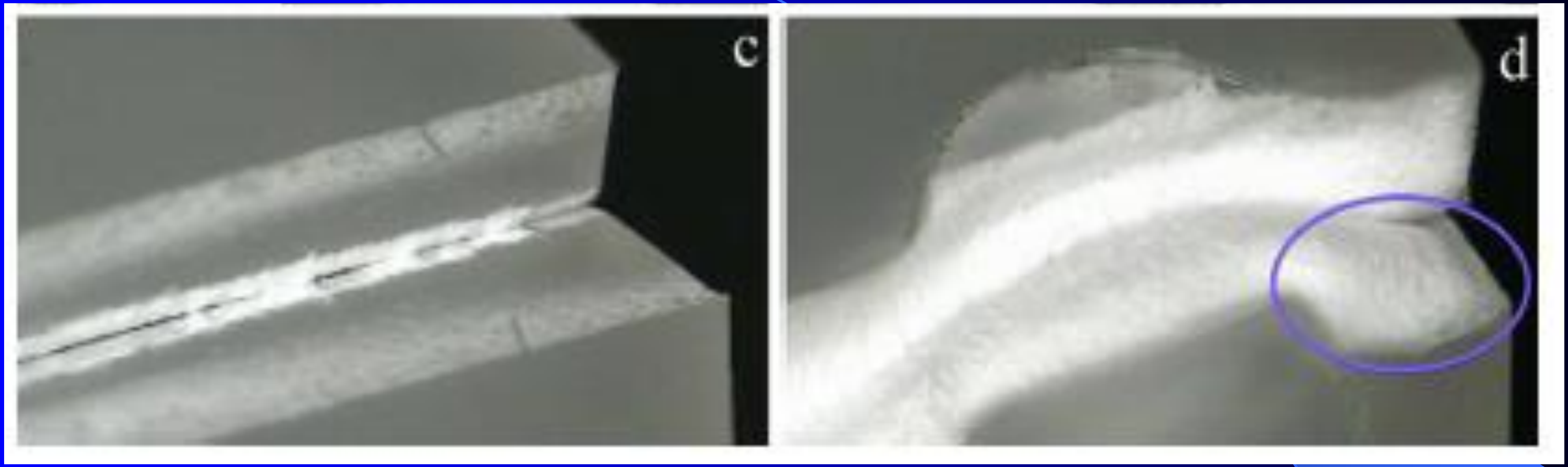
- The IM specimen showed a uniform destructive section along the interface of weld lines.
- An irregular destructive section was observed in the IM-EPCS specimen.
- The reflow melt disarranged the parallel molecular orientation along the interface of weld lines and causes an irregular destructive section.

The Cross Sections of PP Specimens Along Weld Lines (1/2)



- The specimen without weld lines had the largest bending deformation region and had no cracking on its surface.
- An obvious concentration of stress is evident in the IM specimen , and resulting in a narrow and straight band of deformation.
- The crack of IM-EPCS was curved and irregular, and the deformation band was curved and larger than the IM specimen.
- A curved weld line dispersed the bending force, reducing the stress concentration.

The Cross Sections of PP Specimens Along Weld Lines (2/2)



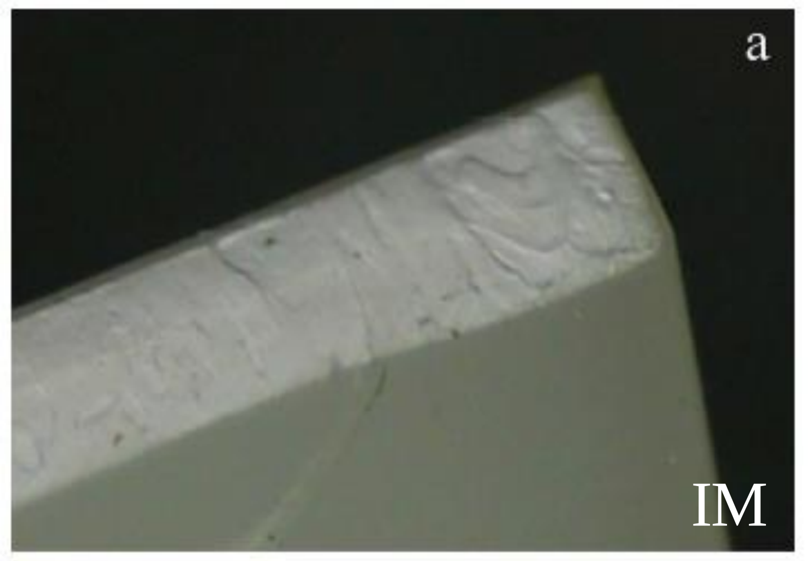
- The IM specimen has a straight flat surface of cracks.
- The cross-sections of the destroyed IM-EPCS specimens show three different broken-phases.

(1) a uniform broken area near the top and side surfaces of the specimen (see marked area), in which the parallel molecular orientation is not eliminated.

(2) an elongated area of deformation on the bottom surface of specimen.

(3) a tensional fracture area between the broken area and the elongated deformation area in which the cross-section of reflow melt pass through and the resin was fractured by the tensile stress of bending.

The Cross Sections of ABS Specimens Along Weld Lines



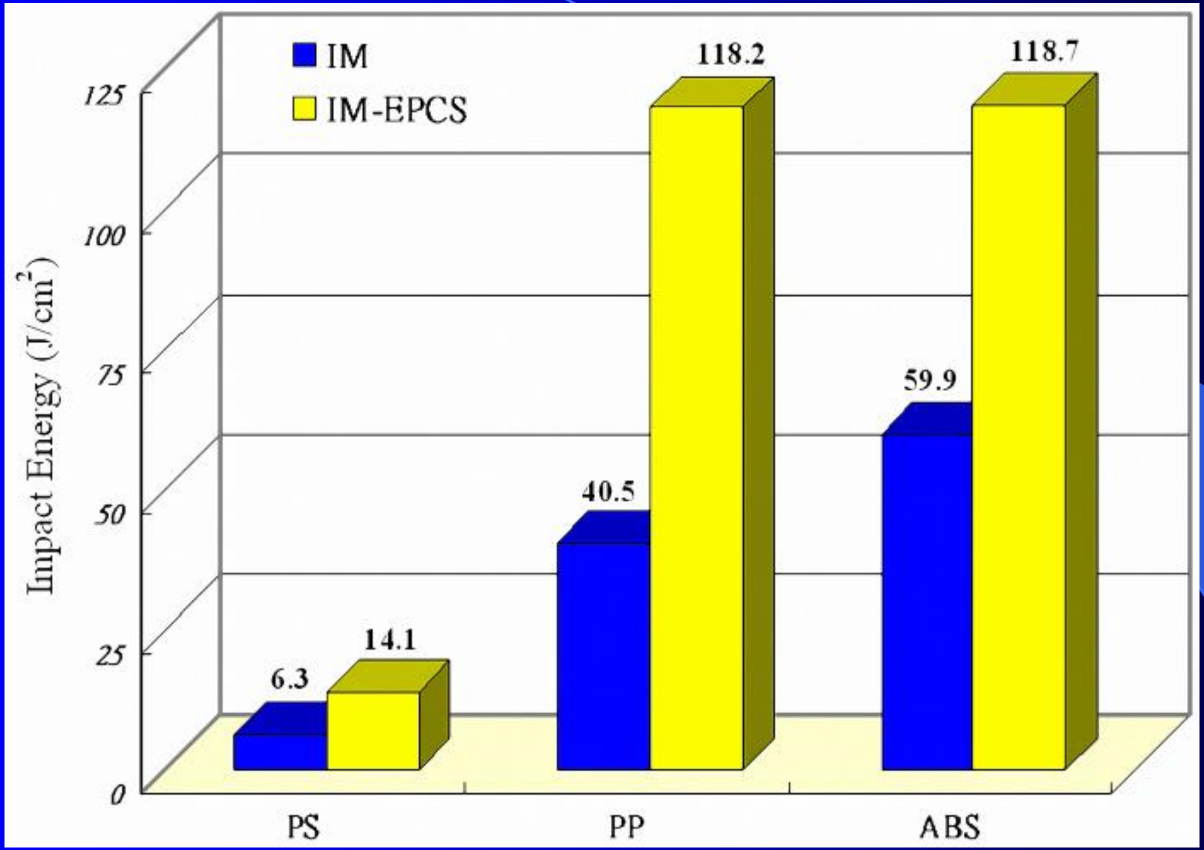
- The IM specimens also present a straight and flat crack along the interface of weld lines.
- The broken cross-section of IM-EPCS is uniform close to the upper surface (marked area), but most of broken cross-sections is irregular.
- The irregular of IM-EPCS broken section provides evidence that the reflow melt has successfully destroyed the parallel molecular orientation of weld line.

Results of Flexural Tests

Materials	Max. flexural stress (Mpa)			Flexural strain (%)		
	No weld line	IM	EPCS	No weld line	IM	EPCS
PS	116.7	36.3	53.1	6.2	2.3	3.5
PP	38.6	32.1	34.7	7.5	4.6	5.9
ABS	88.7	70	74	5.9	4.4	5.3

- The proposed EPCS increase the PS specimens with 46% in maximal flexural stress and 52% in flexural strain.
- The proposed EPCS increase the PP specimens with 8.1% in maximal flexural stress and 28% in flexural strain.
- The proposed EPCS increase the ABS specimens with 5.7% in maximal flexural stress and 20% in flexural strain.

The Comparison of Impact Energy of Specimens with IM and IM-EPCS



EPCS significantly improves the impact properties of weld lines

PS: 124% (increased from 6.3 J/cm^2 to 14.1 J/cm^2),

PP: 192% (increased from 40.5 J/cm^2 to 118.2 J/cm^2)

ABS: 98% (increased from 59.9 J/cm^2 to 118.7 J/cm^2)

Conclusions

- The EPCS can drive the melt reflow through the weld lines and disarrange the parallel molecular orientation at the weld line interface.
- The EPCS EPCS just had limited effect to the maximal tensile stress and tensile strain.
- the proposed EPCS increased the maximal flexural stress of the PS, PP, and ABS specimens by 46%, 8.1%, and 5.7%, respectively, and the flexural strain by 28%, 52%,and 20%.
- the EPCS greatly increased the impact strength of the PS, PP, and ABS specimens by 124%, 192% and 98%
- the EPCS is a feasible and efficient system for reducing the loss of mechanical strength that is caused by weld lines

Thank You !

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