

الخلاصة

[1520°C]  
(mm 100 30 mm ) (mm 30 10 mm )  
(100sec 50sec 10sec 2sec)

**Solidification Of Metals In Die Casting By Using Different Moulds****Ali A. Al-Kayiem****Babylon Univ./College of Eng./Mech. Eng. Dept.**Abstract

This paper includes a theoretical study of solidification of metals in die casting. The melting temperature of steel(chosen in this work) is equal[1520°C] . Several size of mould are investigated of length [from 30 mm to 100mm] and of heights [from 10 mm to 30mm].A two dimensional transient heat conduction equation is derived by adopting the energy balance on an element. This equation is solved numerically by using finite difference method with the suitable initial and boundary conditions. A quick BASIC computer programme is developed to obtain temperature distribution within the cast during the solidification process. different times are chosen [2 sec,10 sec,50 sec and 100 sec] arrivals to solidification of metals.

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$(m^2)$	$=A$
$(kJ/kg^{\circ}C)$	$=C_p$
$(W/m^{\circ}C)$	$=k$
$(kJ/kg)$	$=H_f$
$(W/m^2^{\circ}C)$	$=h$
$(^{\circ}C)$	$=T$
$(^{\circ}C)$	$=T_p$
$(^{\circ}C)$	$=T_0$
$(^{\circ}C)$	$=T_{\infty}$
$(kJ/kg)$	$=q$
$(kJ/kg)$	$=q_s$
$(kJ/kg)$	$=E$
	$(sec) = t$
	$(mm) = H$
	$(mm) = L$
$(kJ/kg^{\circ}C)$	$=C_{eff}$
	$=F_s$

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$(kg/m^3)$	$= \rho$
$Pa.s$	$= \mu$

$$(m^2/s) = \nu$$

$$(m^2/s) = \alpha$$

$$(mm) x = \Delta x$$

$$(mm) y = \Delta y$$

$$(sec) = \Delta t$$

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$$(^{\circ}C) = n$$

$$(^{\circ}C) = n+1$$

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$$(^{\circ}C) x = i$$

$$(^{\circ}C) y = j$$

$$(kJ/kg) = \text{convection}(in)$$

$$(kJ/kg) = \text{convection}(out)$$


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[(2000) ]

[(1997)Mohammed, D.K.]

[(1992) Chawing,H.T. ]

$(10^{10} \text{ k/sec } 10^{-5})$

.[(2001) Seetharamu, K.N. ]

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.[(1992) Ya,K.N.]

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.[(1997) Lewis,R.W.]

Salcudean ,M. ]

(Die Casting)

.[(1988),Abdullah, Z.

. [(1999) Martin, R. Barone ,David A. Caulk ]

.(1981) Brody,H.]

(pressure drop)

.[(1985)Kimo Kubo,Robert D. Peehlke]

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$$(1) \quad q_x + q_y + q_{\text{convection(in)}} + q_m = q_{x+dx} + q_{y+dy} + q_{\text{convection(out)}} + \frac{dE}{dt}$$

$$q_x = -k \frac{\partial T}{\partial x} dy \quad (2)$$

$$q_{x+dx} = - \left[ k \frac{\partial T}{\partial x} + \frac{\partial}{\partial x} \left( k \frac{\partial T}{\partial x} \right) dx \right] dy \quad (3)$$

$$q_y = -k \frac{\partial T}{\partial y} dx \quad (4)$$

$$q_{y+dy} = -[k \frac{\partial T}{\partial y} + \frac{\partial}{\partial y} (k \frac{\partial T}{\partial y}) dy] dx \quad (5)$$

$$\frac{dE}{dT} = \rho c_p dx dy \frac{\partial T}{\partial t} \quad (6)$$

$$q_s = \rho H_f dx dy \frac{\partial f_s}{\partial t} \quad (7)$$

: (1) (7 2 )

$$\rho(c_p - H_f \frac{\partial f_s}{\partial t}) \frac{\partial T}{\partial t} = k \frac{\partial^2 T}{\partial x^2} + k \frac{\partial^2 T}{\partial y^2} \quad (8)$$

$$C_{eff} \quad (8) \quad : \rho(c_p - H_f \frac{\partial f_s}{\partial t})$$

[Hanson ,P.N., (1980)]

$$C_{eff} \frac{\partial T}{\partial t} = k \frac{\partial^2 T}{\partial x^2} + k \frac{\partial^2 T}{\partial y^2} \quad (9)$$

$$\frac{1}{\alpha} \frac{\partial T}{\partial t} = k \frac{\partial^2 T}{\partial x^2} + k \frac{\partial^2 T}{\partial y^2} \quad (10)$$

: (10)

$$\frac{\partial T}{\partial t} = \frac{T_{i,j}^{n+1} - T_{i,j}^n}{\Delta t} \quad (11)$$

$$\frac{\partial T}{\partial x} = \frac{T_{i,j}^{n+1} - T_{i-1,j}^n}{\Delta x} \quad (12)$$

$$\frac{\partial^2 T}{\partial x^2} = \frac{T_{i+1,j}^n - 2T_{i,j}^n + T_{i-1,j}^n}{\Delta x^2} \quad (13)$$

$$\frac{\partial T}{\partial y} = \frac{T_{i,j}^{n+1} - T_{i,j-1}^n}{\Delta y} \quad (14)$$

$$\frac{\partial^2 T}{\partial y^2} = \frac{T_{i,j+1}^n - 2T_{i,j}^n + T_{i,j-1}^n}{\Delta y^2} \quad (15)$$

[(1984) Hong, J. C.P.]  $\Delta x = \Delta y$

$$W = \frac{\alpha \Delta t}{\Delta x^2}$$

: (10) (15 11 )

$$T_{i,j}^{n+1} = W(T_{i+1,j}^n - 2T_{i,j}^n + T_{i-1,j}^n + T_{i,j+1}^n + T_{i,j-1}^n) + (1 - 4W)T_{i,j}^n \quad (16)$$

Boundary condition:

:

$$y = H, \quad T = T_p$$

$$y = 0, \quad -kA \frac{\partial T}{\partial y} = (T_0 - T_\infty)$$

$$x = 0, \quad -kA \frac{\partial T}{\partial x} = h(T_0 - T_\infty)$$

$$x = L, \quad -kA \frac{\partial T}{\partial x} = h(T_0 - T_\infty)$$

Initial condition:

:

$$t = 0, \quad T = T_p$$

(16)

$$(T_\infty = 25^\circ\text{C} \quad T_p = 1520^\circ\text{C})$$

(Surfer)

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(1220°C) : 2 sec (10x30 mm) .

(1460°C)

.( )

(1520°C)

(1050°C) : 10 sec (10x30 mm) .

( 1500°C)

(1400°C)

.( )

(750°C) : 50 sec (10x30 mm) .

(1400°C)

(1300°C)

( 1500°C)

.( )

(550°C) : 100 sec (10x30 mm) .

(1250°C) (1150°C)

(1500°C) (1450°C)

.( )

(1220°C) :2 sec (20x30 mm) .

(1520°C) (1460°C)

(2mm) ( ) (10mm)

.( )

(1150°C ) :10 sec (20x30 mm) .

(1500°C) (1400°C)

( ) .( )

(1520°C)

:50 sec (20x30 mm) .

(x) (L=0) (1500°C)

(1450°C) (5mm)

(1450°C) (1500°C) (1500°C)

.( )

(1450°C) :100 sec (20x30 mm) .

(1450°C) (1400°C) (1400°C)

.( )

(1520°C) :2 sec (30x30mm) .

.( ) (2 sec) (20mm)

:10 sec (30x30mm) .

.( ) (20°C) (1500°C)

(1500°C) :50 sec (30x30mm) .

(x)

.( )

(1500°C)		:100 sec	(30x30mm)	.
	( )			
(1520°C)		:2 sec	(10x50mm)	.
	( )		(1mm)	
( 47mm)	(1500°C)	:10 sec	(10x50mm)	.
	( )		(4mm)	
		:50 sec	(10x50mm)	.
	( )			
		:100 sec	(10x50mm)	.
			( )	
	:		(100 sec)	
(1500°C)		:100 sec	(20x50mm)	.
	.			
			( )	
		:100 sec	(30x50mm)	.
			(30mm)	
(3:4)	(1500°C)		( )	
			(10mm)	
			.	
		:100 sec	(10x100mm)	.
( )			(1:10)	
			( )	
(20mm)		:100 sec	(20x100mm)	.
	( )			

(30mm)  
( )

:100 sec

(30x100mm)  
(1500°C)

( )  
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بين القوالب. ( )

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[(1984) Hong, J.C.P.]

## References

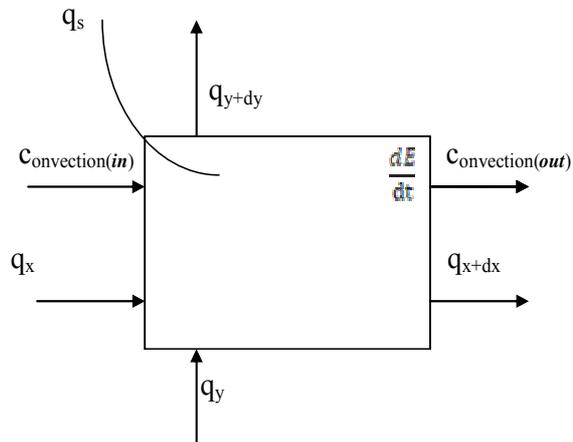
- Al-Bayati,W.A. (1999). **“Production Of A Turbine Blade Using Centrifugal Investment Casting Method”**, M.Sc. Thesis, Baghdad University.
- Brody,H.,Srinath,U.,Hwang,W.,Akgerman,N.,Badawy,A.Nariman,R.,Miller,S.andWassel,T.,(1981) **“Improved Foundry Casting Utilizing CAD/CAM”**,Tech. Repot 12574,U.S. Army Tank-Automotive Command Research And Development Center.
- Chawing,H.T.,Hwang,J.C.,Jong, S.H., Hwang, W.S.,( 1992)**“Temperature Measurement As A Means To Study The Flow And Thermal Behavior Of Molten Metal During Mold Filling”**, Conference Paper, ROC, National Cheng Kung University, Taiwan.
- Hanson,P.N. (1980). **“Solidification And Related Structure As A Function Of Metal/Mould Boundary Temperature”**, Conference Solidification Technology And Cast House, 15-17, September.
- Hong, J.C.P., Umeda,T. and Kimura, Y. (1984). **“Numerical Models For Casting Solidification: Part I”**, Metal Transactions B, Vol. 15B, , p. 91.
- Kimo Kubo and Robert, D. Pehlke,(1985),**“Mathematical Modelling Of Porosity Formation In Solidification ”**,Metallurgical Transactions B,Vol. 16b p359-365.
- Lewis,R.W. ,Seetharamu,K.N.,Prasad, B.,(1997),**“Modelling Of Heat Transfer, Fluid Flow And Thermodynamics In Casting”** ASM Int. p.161-273.
- Martin R. Barone And David A. Caulk ,(1999),**“Analysis Of Liquid Metal Flow In Die Casting ”**, Research And Development Center.
- Mohammed,D.K. (1997).**“Computer Simulation for A casting mould Design”**Ph.D Thesis, Baghdad University.
- Salcudean,M. , Abdullah,Z. ,(1988),**“On The Numerical Modelling Of Heat Transfer During Solidification Processes”**, International Journal For Numerical Method In Engineering ,Vol.25 p445-473.
- Seetharamu, K. N.,(2001)**“Finite Element Modelling Solidification Phenomena”**, Sadhana Vol. 26, Parts1and 2,p.103-120
- Worster,M.G. ( 1986). **“Solidification Of An Alloy From A Cooled Boundary”**, J. Fluid Mech., Vol. 167, p. 481-501.
- Yu ,K.O., Nichols, J.J., Robinson, M.,(1992),**“ Finite Element Thermal Modelling Of Casting Microstructures And Defects”**,J.Oper. Mainten.44:p21-25

" (2000)

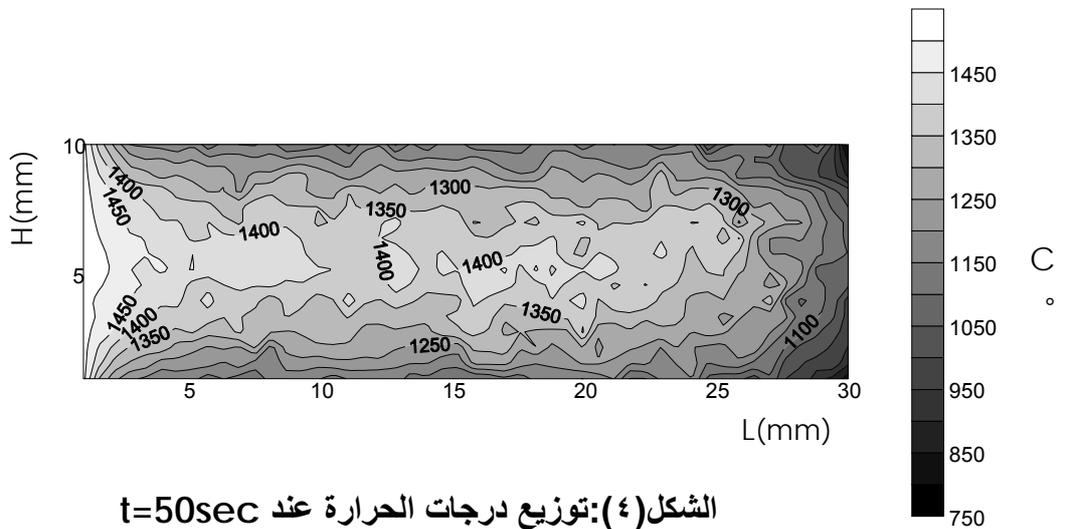
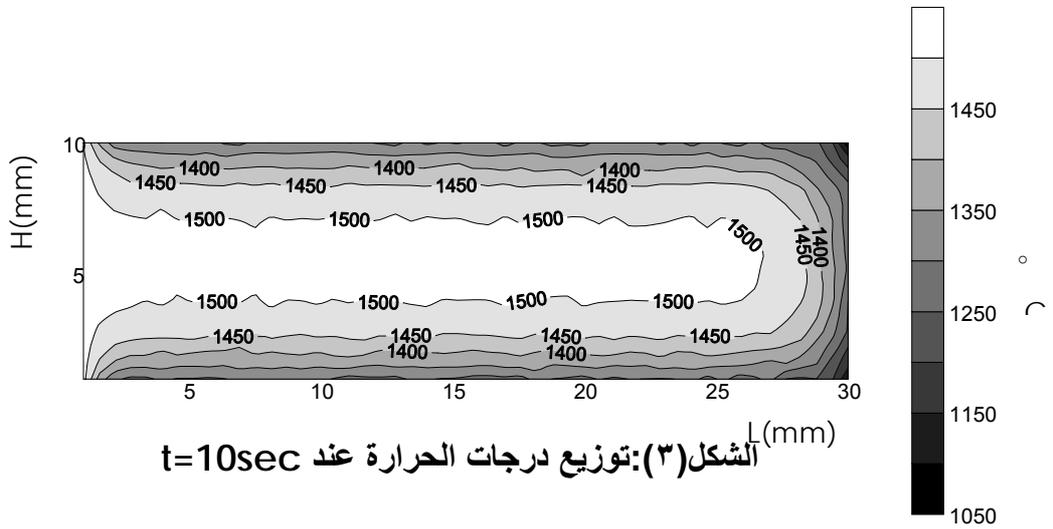
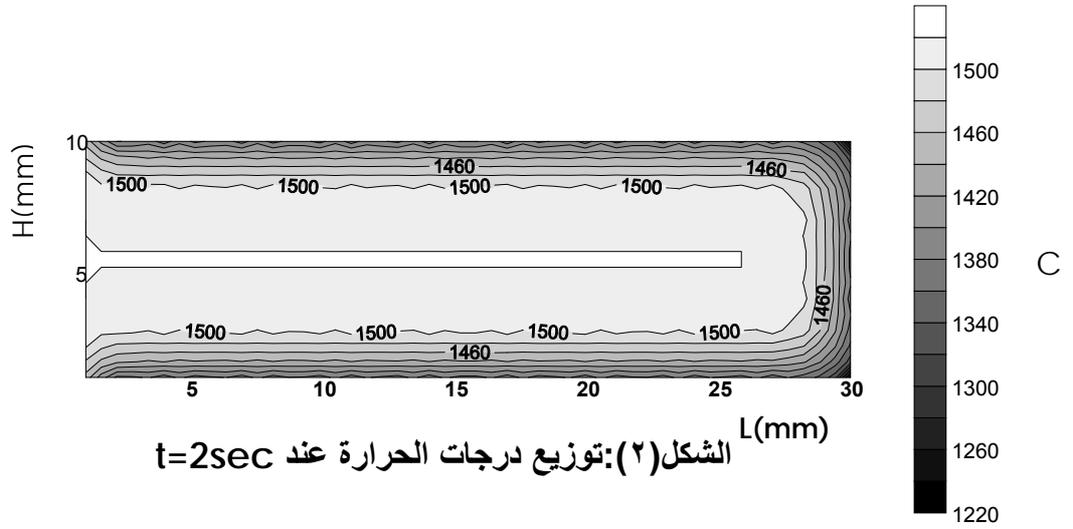
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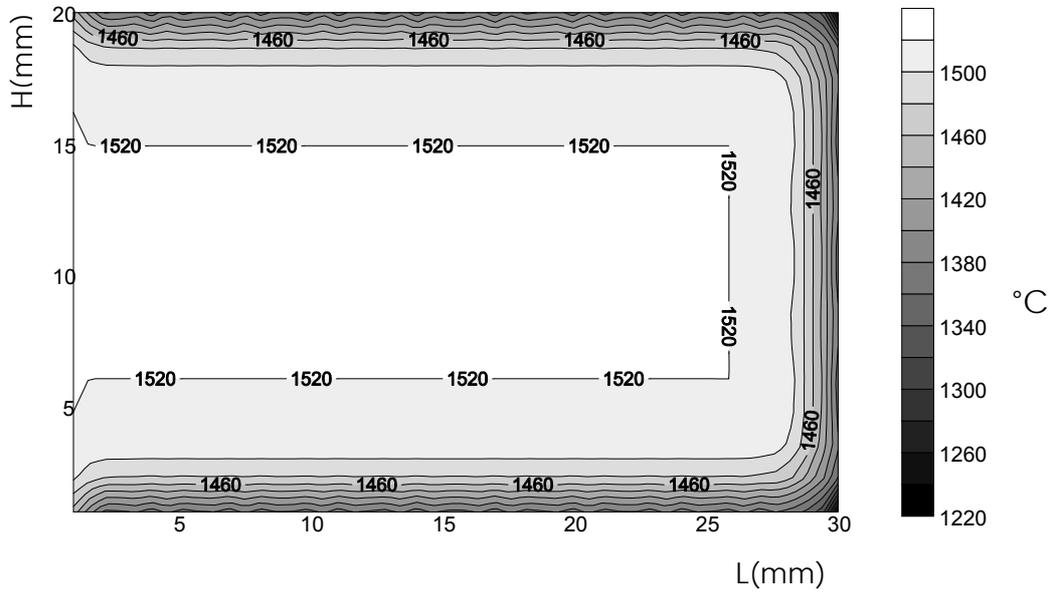
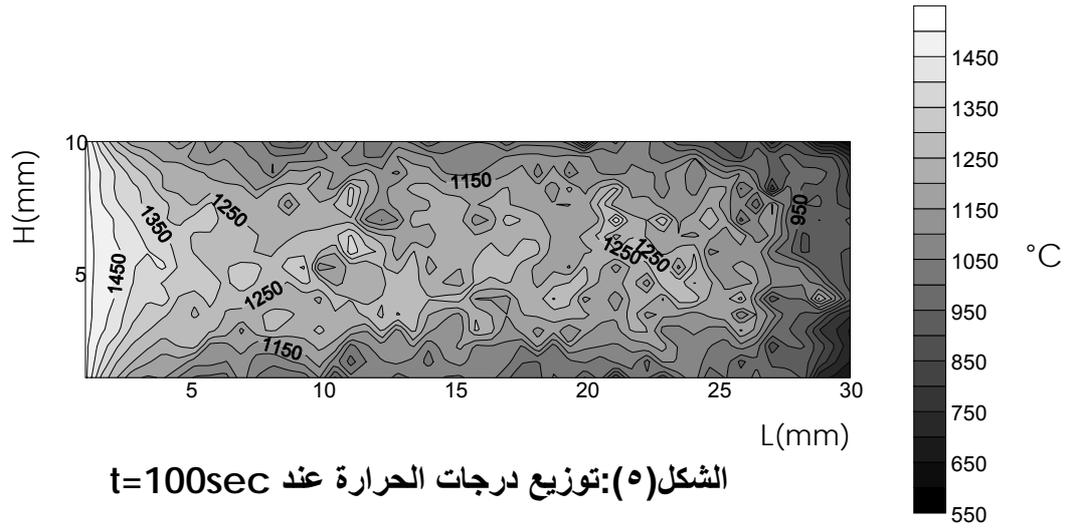
(°C)			(10x30 mm)
1220	1460	1520	2 sec
1050	1400	1500	10 sec
750	1300	1400	50 sec
550	1150	1250	100 sec
			(20x30 mm)
1220	1460	1520	2 sec
1150	1400	1500	10 sec
800	1350	1500	50 sec
600	1300	1450	100 sec
			(30x30mm)
1220	1500	1520	2 sec
1150	1350	1500	10 sec
900	1150	1500	50 sec
800	1000	1450	100 sec
			(10x50mm)
1200	1380	1520	2 sec

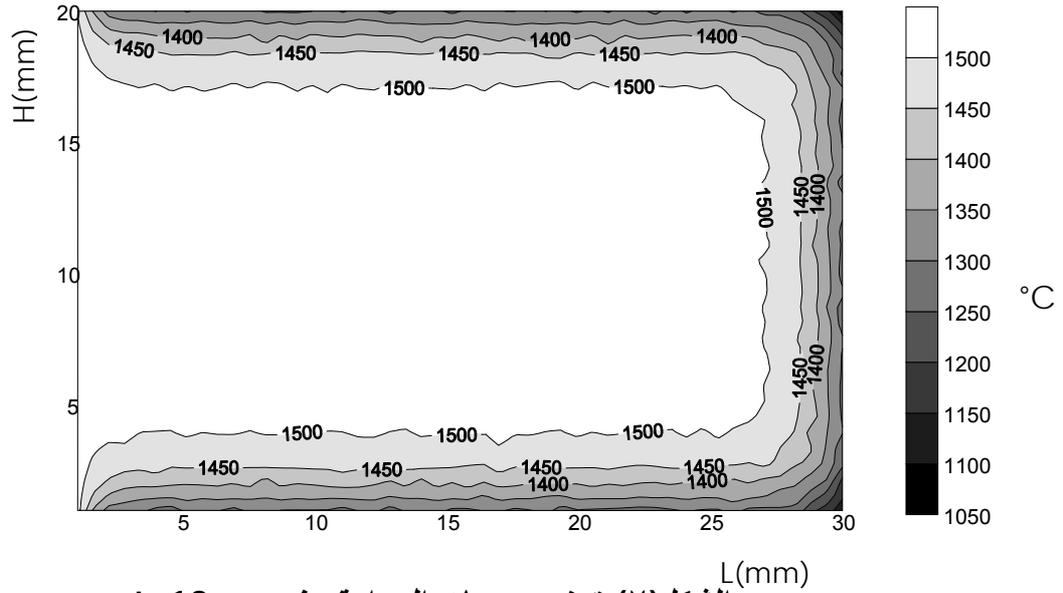
1000	1320	1500	10 sec
800	1250	1350	50 sec
750	1150	1250	100 sec
			100 sec
500	1150	1400	(20x50mm)
600	1200	1500	(30x50mm)
550	1000	1150	(10x100mm)
600	1100	1400	(20x100mm)
650	1200	1500	(30x100mm)



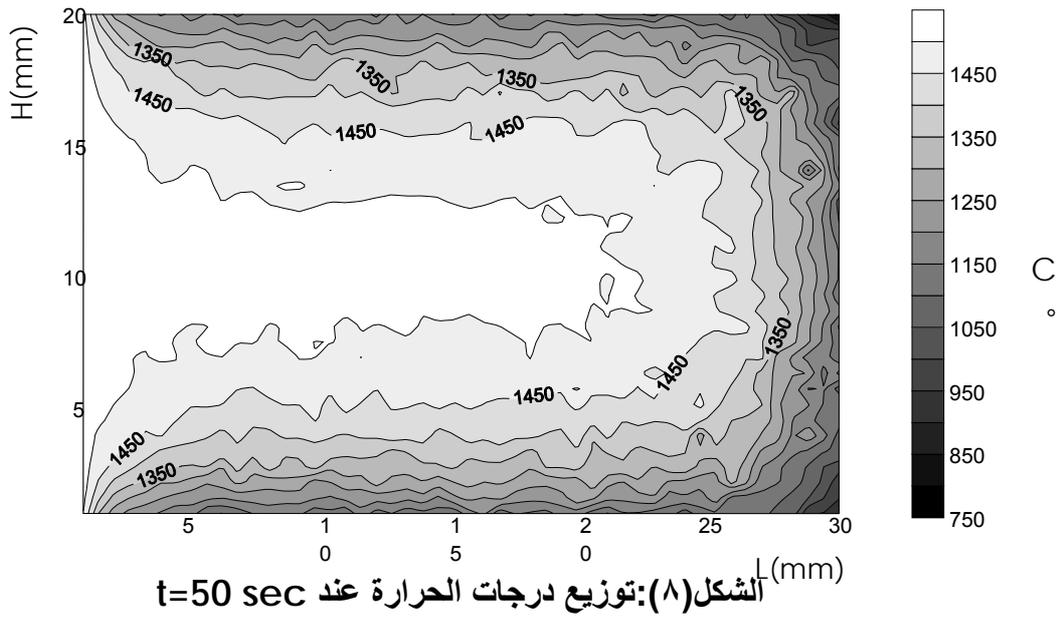
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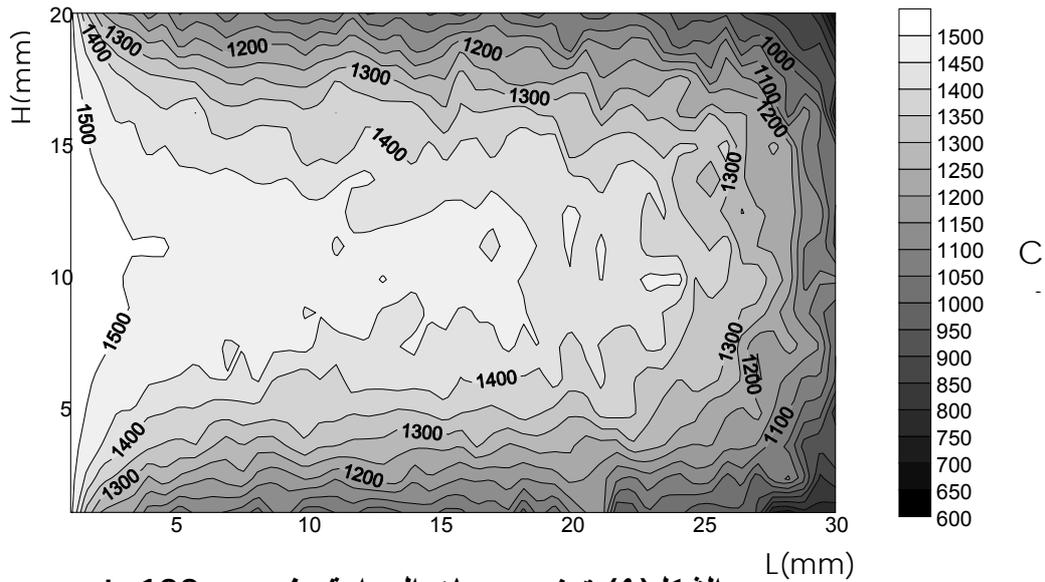




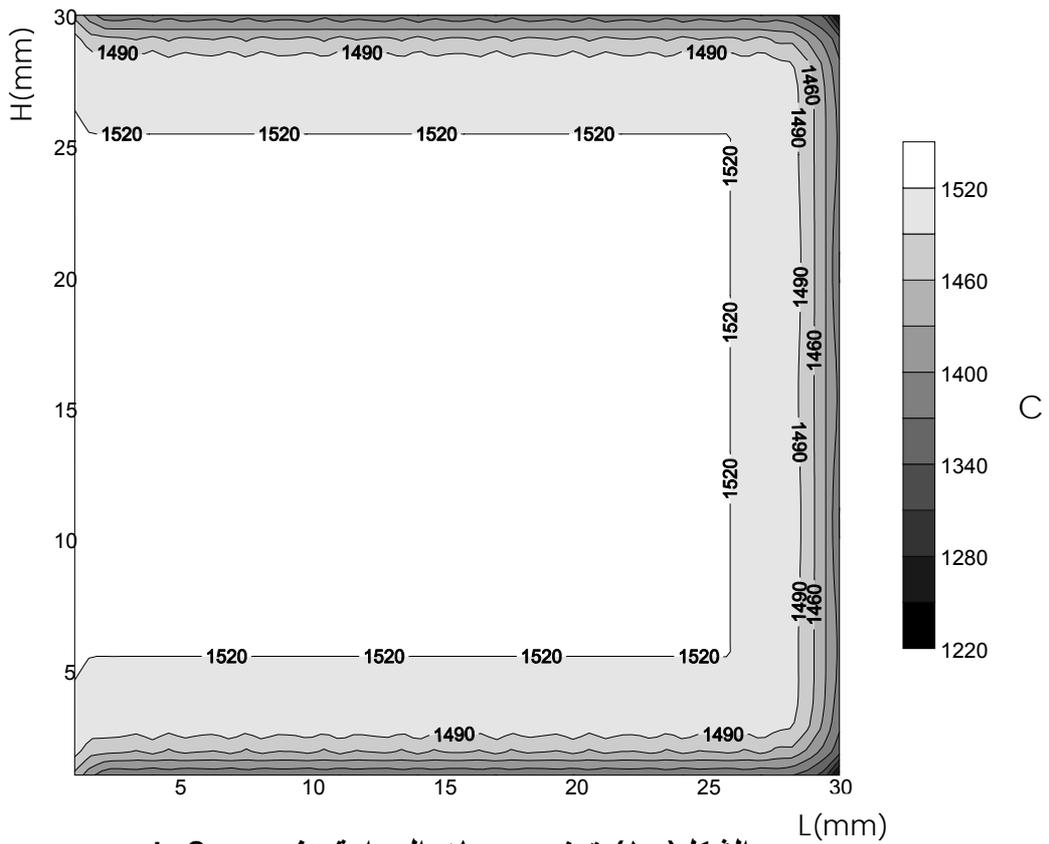
الشكل (٧): توزيع درجات الحرارة عند  $t=10\text{sec}$



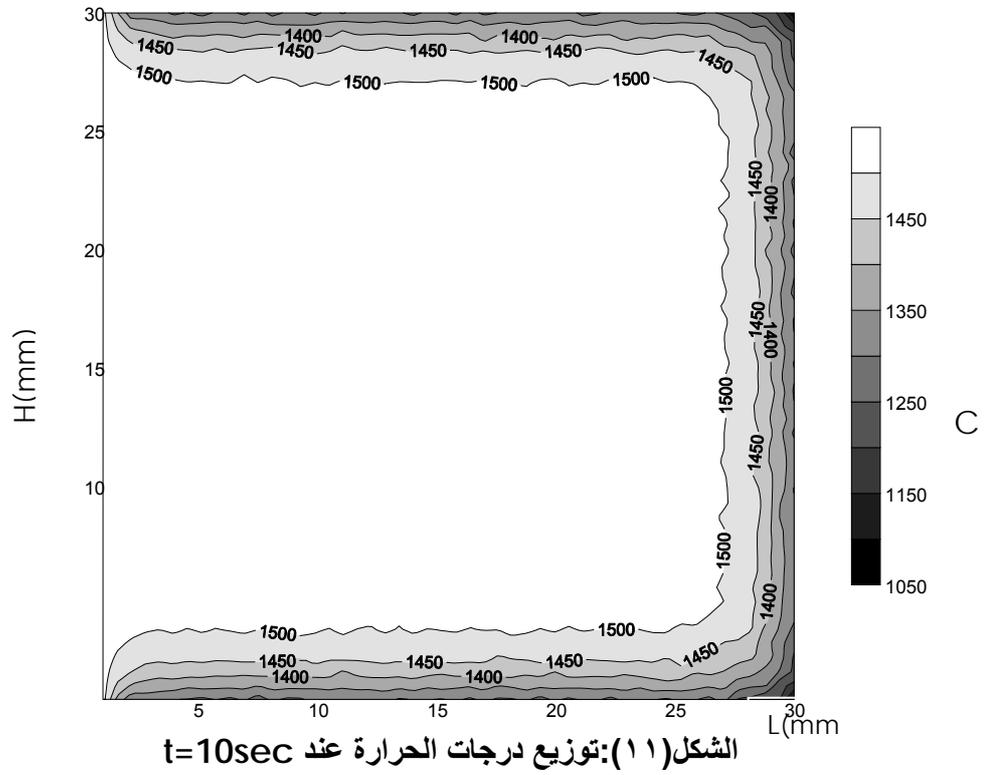
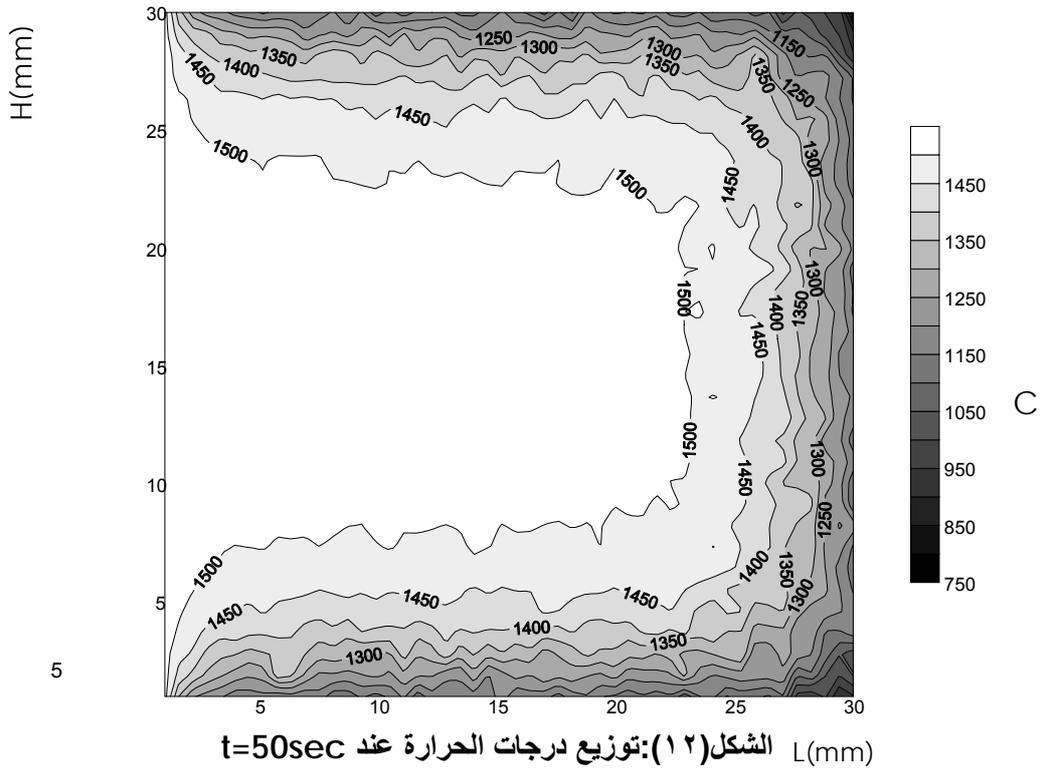
الشكل (٨): توزيع درجات الحرارة عند  $t=50\text{sec}$

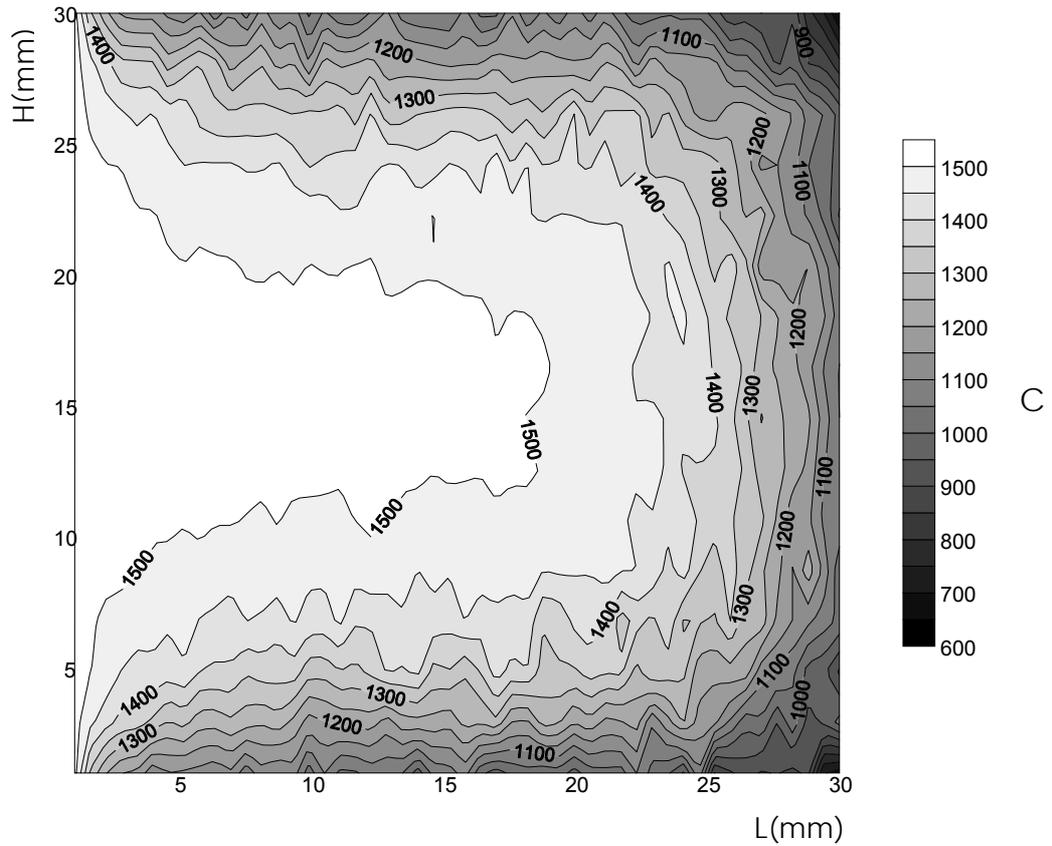


الشكل (٩): توزيع درجات الحرارة عند  $t=100\text{sec}$

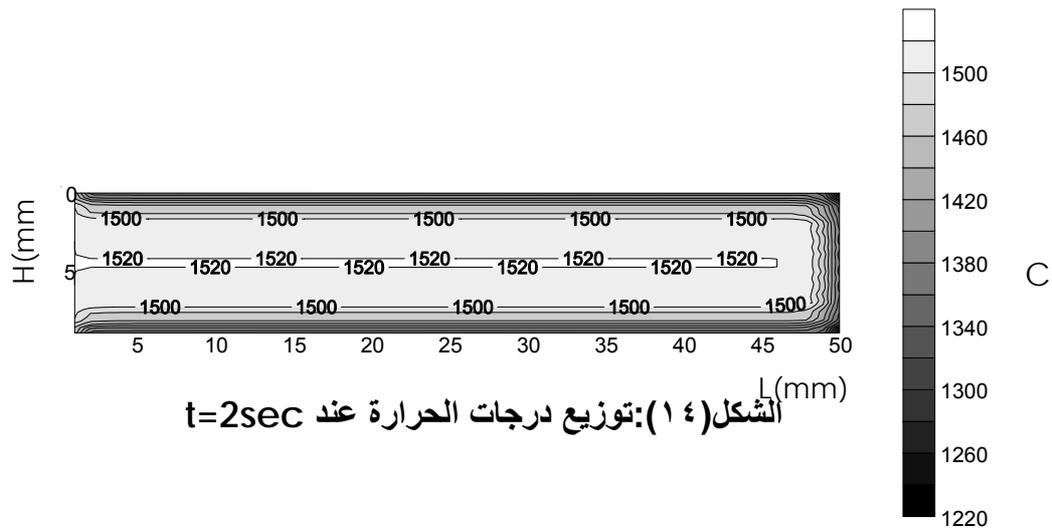


الشكل (١٠): توزيع درجات الحرارة عند  $t=2\text{sec}$





الشكل (١٣): توزيع درجات الحرارة عند  $t=100\text{sec}$



الشكل (١٤): توزيع درجات الحرارة عند  $t=2\text{sec}$

