

*Kauf*

**Mn-Cu**

05.16.01 - «

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« »

: ,

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«

» ( )

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«

« »

: « ( )»

«23» 2019 . 14:00

217.035.01, « . . . » :

105005, . , . , .23/9, .2.

« . . . » <http://www.chemet.net>.

«\_\_\_\_\_» \_\_\_\_\_ 2018 .

217.035.01, . . . , . . .

*H. Asseem*

Mn 60...85 %)

( ) =50 %, ( ) ( = 350í 500 ) ( = 20í 30 %).

Mn; - Mn; - Cu, (3í 4,5 %); - Mn-Cu Mn 50 %, 200í 300 °

Warlimont H., Wang C. P. *et al.* Mn 60...95 %, 80 % Mn, 60í 80 % Mn, (3...5 ) ( 1+ 2) ( 1) ( 2) 50 %

50 % Mn.

Mn-Cu

Mn -  
-Mn,

2011 ( /184);

13-08-97545 \_ \_ ;  
( /49).

16-42-710770 \_

36 75 %

Mn-Cu

Mn

1.

2.

Mn- u

3.

-Mn

4.

Mn-Cu.

5.

Mn-Cu.

1.

36 % Mn

2.

«  
Mn-Cu.»

3.

$f_p^2$

4.

$Q^{-1}$ . , 36Mn64Cu  
( = 13 %)

75Mn25Cu.

Mn-Cu Mn 75 36 . %;

36Mn64Cu

1.

(

2.

3.

2639751

36Mn64Cu.

, 7 C22F

1/16 (2006.01).

Mn-Cu /

» ( ). - 2016129864; . 20.07.2016; . 22.12.2017,

. 36. 6 5 .

: XXI - « -  
 », 2012 ( , ); XXXVIII  
 « », 2012  
 2014 ( , ); 4- 5- -  
 « », 2012 2015 ( , ); VII, IX  
 X ,  
 2012, 2016 2018 ( , ); 9- -  
 ESOMAT-2012 ( - , ); XIII XVI -  
 - -  
 , 2012 2015 ( , ); II IV  
 « ,  
 » (MMSN II IV), 2013 2017 ( , ); VII IX  
 - « » -  
 2014 2018 ( , ); International Conference on Martensitic  
 Transformations ó ICOMAT-2014 (Bilbao, Spain); III -  
 , , , 75-  
 . . , 2016 ( , );  
 « », 2016 ( , );  
 XXXVII- , -  
 70- . . ,  
 2017 ( , ); XXIII , -  
 100- . . . 110- .- .  
 . . , 2018 ( - , ); VII -  
 « -  
 », 2018 ( , ); -  
 « , -  
 », 2018 ( , ).  
 21 , 5 -  
 , .  
 , ,  
 143 .  
 124 , 74 8 .

1.

Mn-Cu.

Mn-Cu,

Mn-Cu.

( ) Mn-Cu  
( )

2.

Mn-Cu

1.

1 -

Mn-Cu\*

	, / .%					
	Mn	Cu	Fe	S	P	
75Mn25Cu	76,0/73,7	22,3/25	0,8/0,8	0,44/0,25	0,45/0,25	1,69/1,3
36Mn64Cu	39,5/36,1	60,36/63,79	-	0,12/0,10	0,02/0,01	0,14/0,11

\*-

«

»

ó

36Mn64Cu;

75Mn25Cu

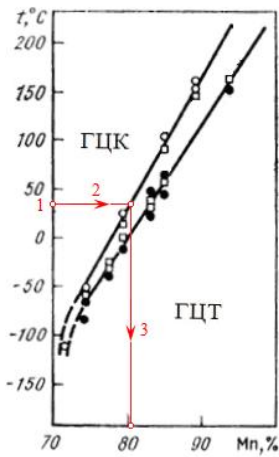
NaCl

400, 440 540 °

300 ° ;

$10^{-5} \dots 10^{-4}$ ;

$2 \dots 5$  ° / ;  
 $\sim 10^{-2}$   
45...55



$f_p^2$  ( )

( 1),  
Mn

1 ó

Mn-Cu [Basinski Z. S. 1952]

« -3» Cu

$\pm 5 \cdot 10^{-4}$  3í 5 %

« -3»  
100 .

( ) 1°

Observer. DIm (  $\times 50 \dots \times 2500$ ).

«Phenom ProX»  $\times 500$ í  $\times 10000$ .

9450-76  
10 .

1

$\pm 3$  V.

92538).

(  
 $M_s$   $M_f$  ;



) ( )  
 =1...5 %.

$$: = \frac{\gamma - \gamma}{\gamma} \cdot 100\% .$$

10 %.

3.

Mn-Cu c

Mn 75 36 %

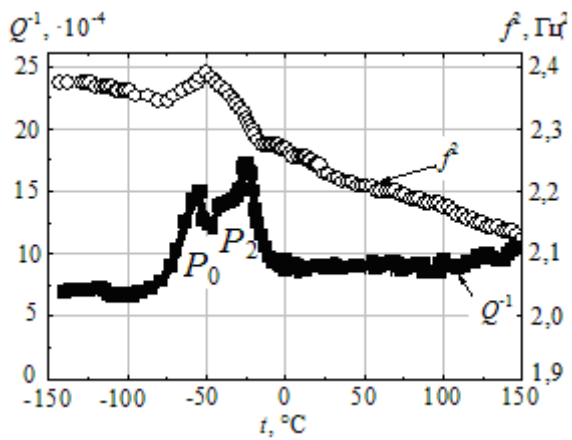
36Mn64Cu 75Mn25Cu

= 0,3703±0,0005 = 0,3768±0,0005 ,  
 36Mn64Cu 75Mn25Cu 123 120 HV,

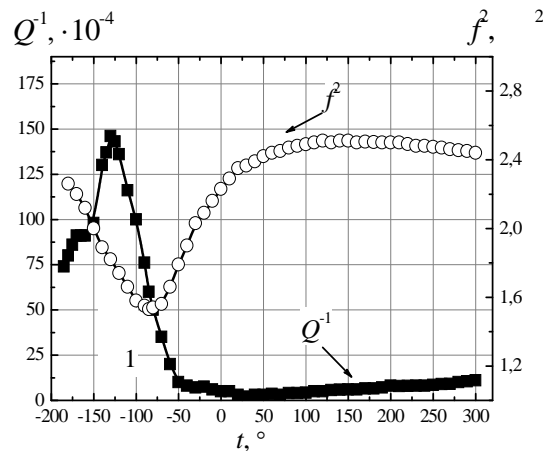
( )

36Mn64Cu

-  $P_0$  (  $max \approx -58^\circ$  )  $P_2$  (  $max \approx -32^\circ$  ),  
 ( 2, ).



2 ó  $f_p^2$



36Mn64Cu ( ) 75Mn25Cu ( )

$P_0$  2,

( ).

$$0 (Q_{max}^{-1} - Q_f^{-1})$$

( 2),

$H \sim 11,4...11,7$  / . ,

$^{36}\text{Mn}^{64}\text{Cu}$

$^{75}\text{Mn}^{25}\text{Cu}$

1,

(  $f_p^2$  ) ( 2, ). (-80 °C),

$f_p^2$ ,

$\approx 74\% \text{ Mn}$  ( 1).

$^{75}\text{Mn}^{25}\text{Cu}$

$^{75}\text{Mn}^{25}\text{Cu}$  ( 3, )

( $P_3$  1).

$P_3$

$P_1$

$f_p^2$

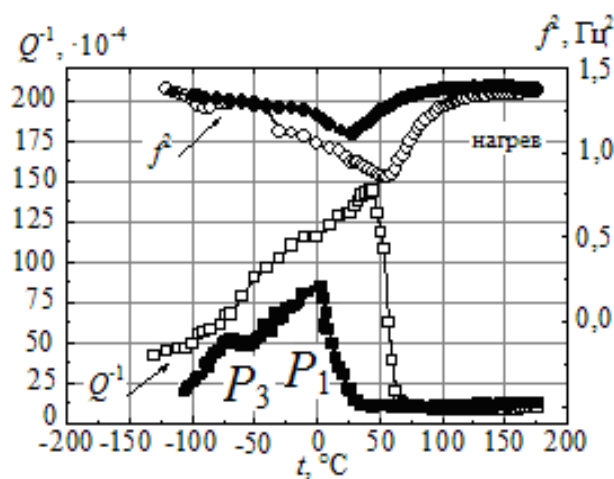
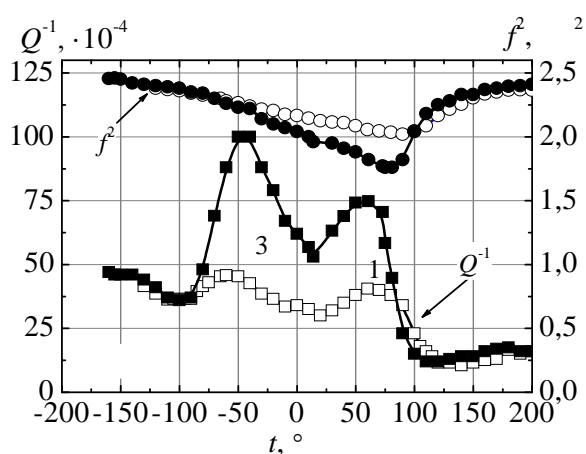
$f_p^2$

$^{36}\text{Mn}^{64}\text{Cu}$

$f_p^2$

$^{75}\text{Mn}^{25}\text{Cu}$

( 3, ).



3 -

$f_p^2$

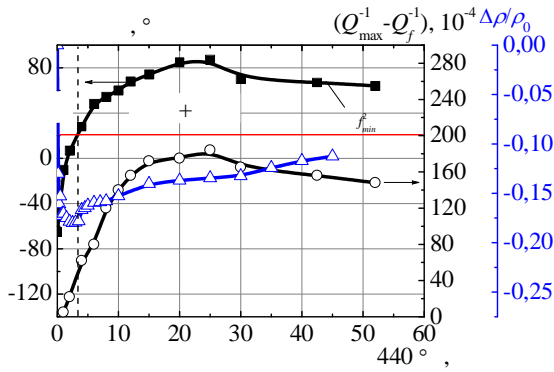
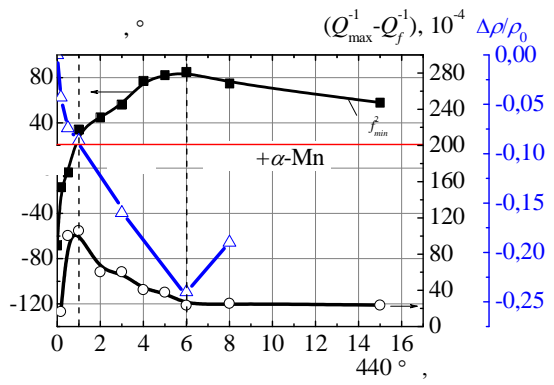
$^{75}\text{Mn}^{25}\text{Cu}$  ( )  $^{36}\text{Mn}^{64}\text{Cu}$  ( )

440 °

: 64; 68

( 4, 5),

( 5).



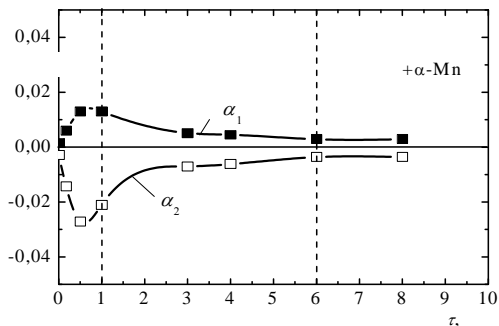
4 - ( 1 )

440 ° , 75Mn25Cu ( )  
36Mn64Cu ( )

~20 °

« »

( 6 ).

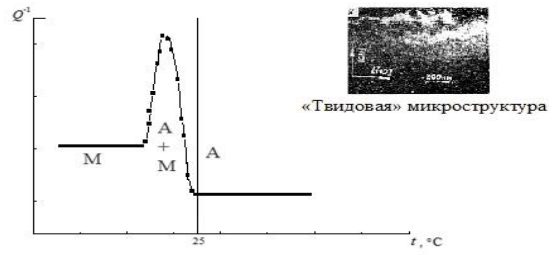


6 -

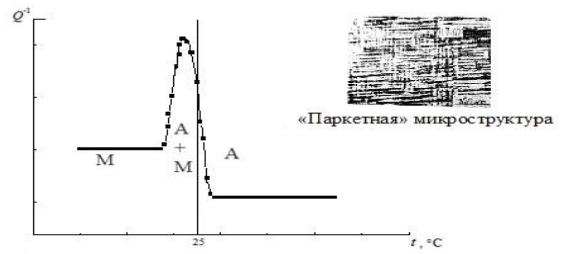
( 1 )

( 2 )

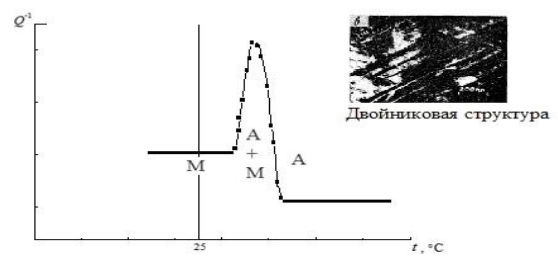
36Mn64Cu ( )



«Твидовая» микроструктура



«Паркетная» микроструктура



Двойниковая структура

5 -

- [ 1991, 2005 ]

75Mn25Cu

M

1 + 2 ( ) ,

440 °

75Mn25Cu ( )

( 1 2),

75Mn25Cu 36Mn64Cu,

1 2  
1 ,  
« ».

75Mn25Cu

Mn 2. ,  
« »  
/ ≈0,98.

-Mn,

Mn -

( )

75Mn25Cu

400 540 °

75Mn25Cu

540 ° -

400 ° ó

36Mn64Cu

( 4, ).

- / ≈0,997,

-Mn

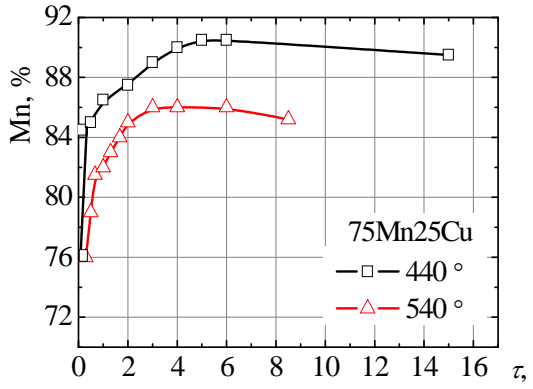
52-

( 1)

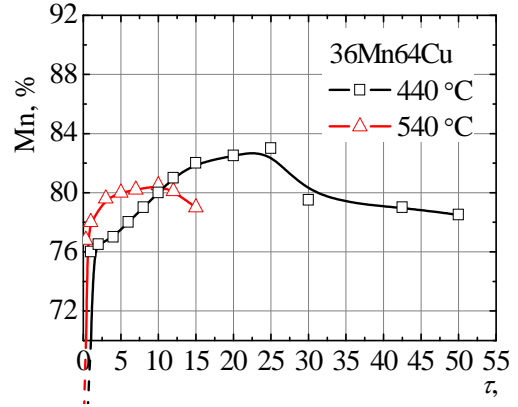
Mn

( 7).

540 °



7 - Mn



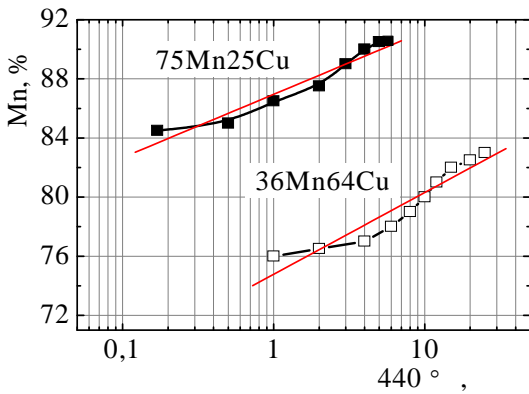
75Mn25Cu ( ) 36Mn64Cu ( )

36Mn64 u

(75Mn25Cu 36Mn64Cu)

( 8).

36Mn64Cu

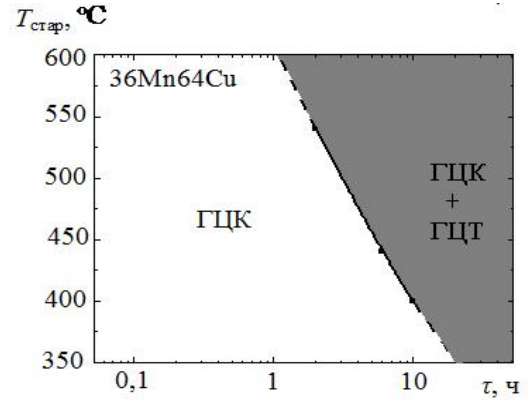
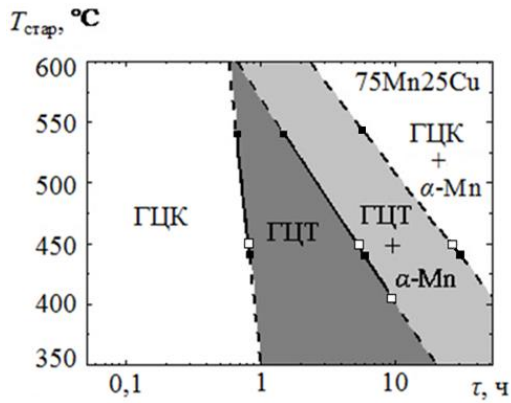


8 ó

Mn

Mn-Cu

75Mn25Cu 36Mn64Cu ( 9),



9 ó

( - ; - , . . , . . . 1980 .)

-Mn.

-Mn

75Mn25Cu

440 540 ° .

-Mn

-Mn; n ó

; ó

n

-Mn

(n é 0,92)

-Mn

540 ° ó 2 ,

440 ° ó 30

( 540 ° ó 2 ,

(n é 0,04).

-Mn

Mn

4.

Mn-Cu

36Mn64Cu 75Mn25Cu.

$(\gamma = 3,2 \cdot 10^{-5})$

75Mn25Cu

$(Q_{max}^{-1} - Q_f^{-1})$ .

$(Q_{max}^{-1} \approx 140 \dots 150 \cdot 10^{-4})$

$\gamma = 3,2 \cdot 10^{-5}$

36Mn64Cu

$(-150 \dots -50^\circ)^\circ$

$(Q_{max}^{-1} \approx 10 \dots 16 \cdot 10^{-4})$

$\gamma = 2,7 \cdot 10^{-5}$

$(-70 \dots -20)^\circ$

440í 450°

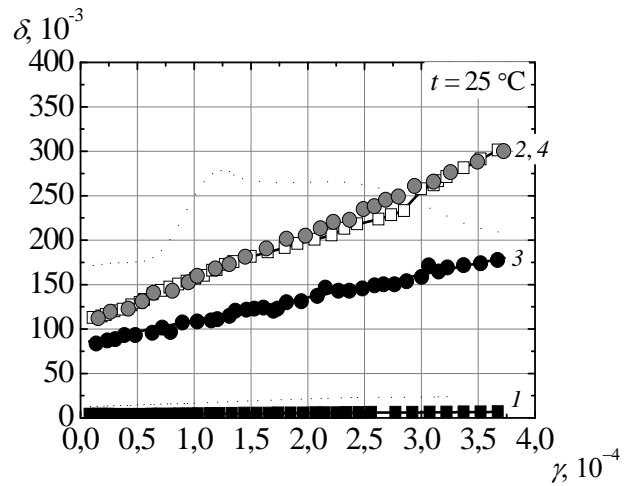
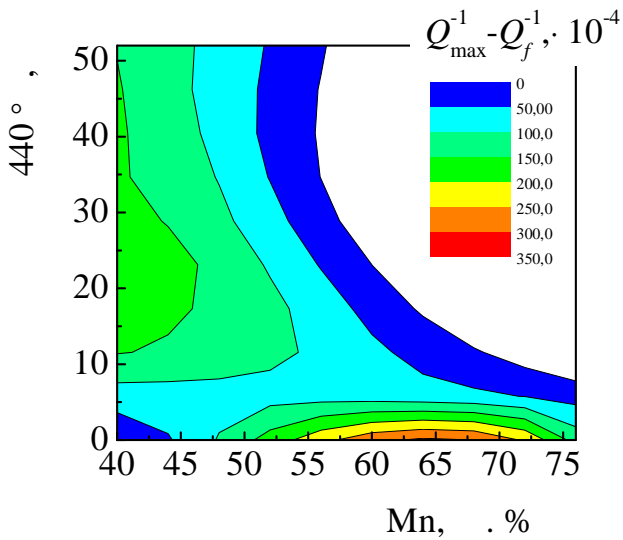
36Mn64Cu 75Mn25Cu,

( 40 76 .%)

$(Q_{max}^{-1} - Q_f^{-1})$

$\gamma = 3,2 \cdot 10^{-5}$  ( 10).

10,



10 -

Mn-Cu  
Mn  
440° (  $\epsilon \approx 3 \cdot 10^{-5}$ )

11 ó

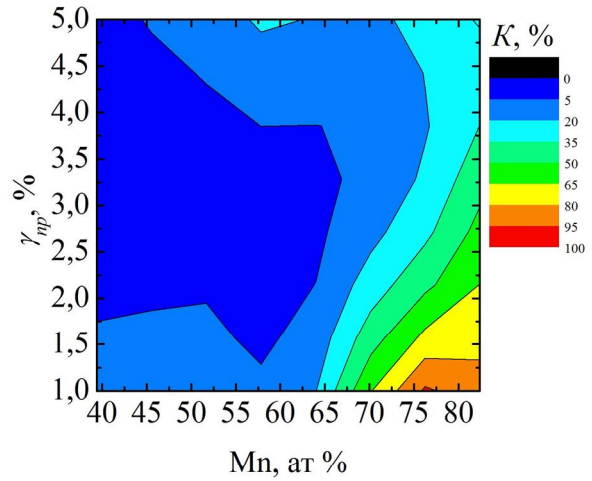
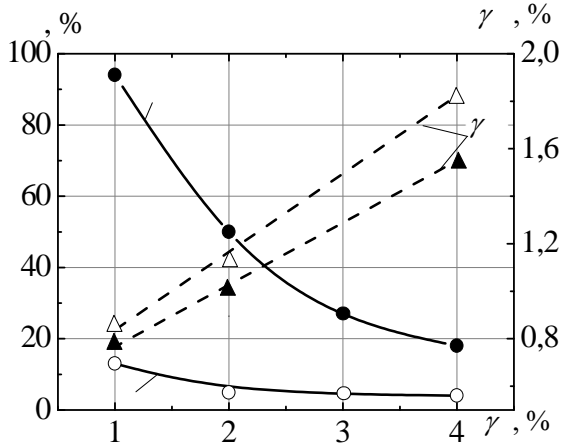
36Mn64Cu :

( - 1);  
440° , 6 ( - 2);  
, 3840 ( - 3);  
(● - 4)

( ) .

, , . -  
 ( 11). -  
 , -  
 . , . -  
 ( + 440 ° ) ( 11). , -  
 . -  
 Mn-Cu . -  
 Mn-Cu, -  
 , -  
 , . -  
 . ( 11). , -  
 Mn-Cu , -  
 . (11 5 %) -  
 ( - , -  
 - , ó - , -  
 - ) 36Mn64Cu 75Mn25Cu. -  
 . -  
 , . -  
 , 400 ° 41 6 . -  
 , Mn-Cu -  
 . , -  
 . ( 12), -  
 . 36Mn64Cu -





12 -  
 75Mn25Cu ( ) 36Mn64Cu  
 ( ê ) 830 ° 10 % -  
 NaCl 400 ° , 6

13 -  
 Mn-Cu

13  
 Mn-Cu

1.

36Mn64Cu 75Mn25Cu,  
 36Mn64Cu

2.

36Mn64Cu

$0 (T_{Q_{max}^{-1}} = -61^\circ ; Q_{max}^{-1} = 8 \cdot 10^{-4})$

$(T_{Q_{max}^{-1}} = -32^\circ ; Q_{max}^{-1} = 16 \cdot 10^{-4}; = 11,4 \text{ i } 11,7 / ) -$

3.

MnCu,

-130 85 °

75Mn25Cu -65 87 ° 36Mn64Cu

4. ,

5. , -

36 n64Cu

52 - 440 ° . , -

Mn , -

6. -

36Mn64Cu 75Mn25Cu -

(75Mn25Cu) -

(36Mn64Cu) .

7. , -Mn 75Mn25Cu -

1,3 , 540 ° , -

-Mn -

8. 440 ° ( = 0í 52 ) ( 40 75 . %) -

$Q^{-1}(\% \text{ Mn, } )$  ,

9. 36Mn64Cu .

( 2639751). -

10. 400 °C, 4 - 6 : ( = 100 %) -

75Mn25Cu ( = 13 %) 36Mn64Cu -

=1 % . -

1. ... // ... 2012. 6. 6. 7. 11.

Markova G. V., Labzova L. V., **Klyueva E. S.** Internal friction in alloys with shape memory effect // Metal Science and Heat Treatment, Vol. 54. 5-6, (2012), pp. 271-275.

2. Markova G. V., **Klyueva E. S.** Internal friction during reverse martensitic transformation in Mn-Cu alloy with 45 % Mn. // Materials Science Forum Vols. 738-739, (2013), pp. 183-186.

3. G. V. Markova, D. M. Levin, S. Kazharskaya, **E. S. Klyueva**, G. Tateladze, E. Bannikova, I. K. Popovichenko The effect of spinodal decomposition on martensitic transformation and shape memory effect in Mn-Cu alloys // Materials Today: Proceedings, Vol. 2S3, (2015), pp. 8416844.

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Mn-Cu / ... ;  
« »

( ) .- 2016129864; . 20.07.2016; . 22.12.2017, . 36. 6 5 .

6. ... Mn45Cu55 // i IV  
i «C i  
i i » ó i : « i », 2012. . 37-39.

7. 36Mn64Cu // III  
: . III . . . - : - . .  
- . . . , 2016. . 113-117

8. Mn-Cu // IV  
./ . . . . ó : - . . - . . -  
, 2017. ó .15620.

9. . . . .  
Mn75Cu25 //
- «Prospero». ó 2014. ó 2. ó . 82 ó 85.
10. . . . .  
75Mn25Cu // -  
. . . . 11. . 2. ó : - , 2016. ó 592 . . 166-174.
11. . . . -Mn Mn-Cu  
25 % Cu // .  
XXXVIII ó .: , 2012. ó . 57-58.
12. . . . -  
Mn-Cu 45 75 . % Mn. // XL  
9 . . . , 7-11 2014 . .: , 2014. .1. .66-68.
13. . . . .  
Mn // . VII-  
« » - 2014 - .:  
, 2014. - . 124.
14. . . . .  
40Mn60Cu // i V  
i - i «C i  
i . i » ó i : « i », 2015. ó . 50-51.
15. . . . .  
40Mn60Cu // -  
. 85- . . . .  
. : - , 2016. ó . 36.
16. . . . .  
Mn-Cu// -  
: . I , ó , 2016. ó . 14.
17. . . . . Mn-Cu //  
XXIII , 100-  
. . . . 100- . . . . : .  
. ó .: - , 2018. ó . 309.
18. . . . . -  
Mn-Cu // .  
« : » ó  
: - , 2011. ó . 17-19.

19. . . . -  
Mn-25 % Cu // . XIII -  
- . ó -  
: , 2012. ó . 84-86.

20. . . . -Mn -  
75 25- // XXI - . ó  
: - . . . . - . . . , 2012. ó . 247-  
248.

21. . . .  
40Mn60Cu // XVI  
- - ( -  
, 7-11 2015 .) 2 . . 2. ó : , 2015. ó . 112-  
114.