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BRIDGEPORT BRASS COMPANY

AEC RESEARCH AND DEVELOPMENT REPORT

EXPERIMENT NO. U- 21

EXTRUSION OF I&E 'O' SIZE TUBING TO EVALUATE
REDUCTION IN EXTRUDED O.D. AND THE USE
OF PRESSED SALT FOLLOWER BLOCKS

J. F. PUTERBAUGH

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EXTRUSION OF I&E 'O' SIZE TUBING
TO EVALUATE REDUCTION IN EXTRUDED O.D.
AND THE USE OF PRESSED SALT FOLLOWER BLOCKS

by

J. F. Puterbaugh

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11-03-94

January 31, 1961

Bridgeport Brass Company
Adrian, Michigan

Contract AT-(30-1)-1405

D. R. Jefferson
A.E.C. Contract Manager

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EXPERIMENT U-21

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EXTRUSION OF I&E 'O' SIZE TUBING
TO EVALUATE REDUCTION IN EXTRUDED O.D.
AND THE USE OF PRESSED SALT FOLLOWER BLOCKS

SYNOPSIS

Pressed salt (NaCl) follower blocks under various conditions of pre-heat temperature were compared with the standard graphite at 800°F. Even though some yield reduction results, it was concluded that pressed salt follower blocks at 300°F represent a substantial cost reduction due to the extreme price differential of the two perishable items.

Extruded O.D.'s of .020" and .040" less than the standard (nominal) 1.50" represent no gain in yield due to the sharp increase in machined slug rejects for O.D. defects.

DECLASSIFIEDINTRODUCTION

The Bridgeport Brass Company is in the process of developing an acceptable and competitive extrusion process for the production of I&E '0' size hollow tubing. Previous experiments have been concerned with the quality of the as-extruded tubing from the standpoint of the number of rejects for various causes. Subsequent experiments will aim toward a final yield optimization, semi-production extrusion. This extrusion experiment was designed to study the effect of a potential extruded O.D. reduction and thus a metal saving per extrusion, and the use of pressed salt follower blocks as a cost reduction item.

Since, in the extrusion process, all metal that can be extruded through the die becomes part of the product and there is a limit, due to the maximum billet size, of the amount of metal that can be extruded per push, any potential increase in the amount of product per push represents a substantial improvement in the process yield. Also, since the follower block is a one-use expense item; that is, one is used per push, a potential cost reduction in this item could represent a substantial process improvement.

OBJECT

The object of this experiment was to extrude normal uranium hollow billets to I&E '0' size tubing with reduced extruded O.D. and also to evaluate the use of pressed salt follower blocks.

PROCEDURE

Twenty-seven hollow cast normal uranium billets 7" O.D. x 2" I.D. 18-21" length were received from National Lead of Ohio and extruded the week of March 13, 1960. All billets were given a three cycle beta heat treatment before extrusion. The 27 billets were divided into nine batches of three billets each to make use of a random balance design. The variables were as follows: (1) die size - 1.520" (standard), 1.500", and 1.480". These represent standard 1.500", 1.480", and 1.460" as-extruded O.D. sizes. (2) follower blocks - pressed salt at a pre-heat temperature of 300°F, pressed salt at pre-heat temperature of 400°F, and a graphite at a pre-heat temperature of 800°F (standard). In addition, (3) these were randomized throughout the three days of extrusion. Figure 1 sketches the

PROCEDURE (continued)**DECLASSIFIED**

experimental design.

Pressed salt follower blocks were made to the same dimensions as used for graphite follower blocks. These were made by the same process as used for making cattle salt licks by the Roto Salt Company, Union Springs, N.Y.

Following the extrusion, the tubes were cut into three sections each with a maximum length of 11 feet. These were processed through cleaning and straightening operations, packed twelve sections per bundle, and shipped to the Mallinckrodt Chemical Works for machining to I&E 'O' size HAPO slugs. In addition, samples were taken for laboratory examination and as a check on the amount of rear crop necessary with the different follower blocks. Figure 2 shows the processing sequence following extrusion. A measurement was taken of the rear crop from each extrusion. This, together with the weight per tube shipped was used to calculate the yield from the various follower block techniques.

The machining of the tubes to slugs at Mallinckrodt Chemical Works was followed to determine if the number of slugs per extrusion was affected by different follower block techniques, and to evaluate the potential O.D. reduction.

FIGURE 1EXPERIMENTAL DESIGNU-21**DECLASSIFIED**

Die - 1.50 FB - Salt 300°F Date - 3/16	Die - 1.52 FB - Salt 300°F Date - 3/17	Die - 1.48 FB - Salt 300°F Date - 3/18
Die - 1.50 FB - Salt 400°F Date - 3/18	Die - 1.52 FB - Salt 400°F Date - 3/16	Die - 1.48 FB - Salt 400°F Date - 3/17
Die - 1.50 FB - Graphite Date - 3/17	Die - 1.52 FB - Graphite Date - 3/18	Die - 1.48 FB - Graphite Date - 3/16

Each Square-Condition Represents
Three Billets

FIGURE 2

PROCESSING SEQUENCE
I&E TUBES

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DECLASSIFIEDDISCUSSION OF RESULTS

The attached Extrusion Data Sheets (Table I) show the conditions and data pertinent to the extrusion. Through a failure in the temperature indicator of the salt bath, the first day's billets were extruded from a furnace temperature of 1200°F. This was corrected to the specified 1150°F furnace temperature on the second day. It is felt that the 50°F difference did not affect the results of this experiment, in view of the design allowing for averaging out of non-critical factors.

During the extrusion run, it was found that the two temperature conditions of the salt follower blocks did not seem to bracket the optimum use and thus the evaluation would be inconclusive. Accordingly, three (3) other temperature conditions were added in order to obtain the most information.

On the second day's run, the balanced design was altered by running two successive groups of three billets each from the same die. However, the changes in the other variables were made as specified by the experimental design. This alteration in the experiment left the standard 1.52" O.D. die size (1.50" O.D. extrusion) with a deficiency in the number of billets. However, it is felt that a sufficient number of billets were extruded under all conditions to evaluate the factors being considered. The experimental design, as actually performed, is shown in Figure 3:

To evaluate the factors in this experiment, certain data was considered valid as indicators for each factor. Crop length and % yield of tube weight shipped from billet weight extruded were used for evaluation of the follower blocks. In the evaluation of a potential yield increase due to decrease of the extruded O.D., the percent O.D. defects from final machined slug inspection was used, with the overall yield added for further information.

Table II lists the consolidated data for the evaluation, by billet number. This includes: (1) billet weight, (2) shipped extrusion weight, (3) number of slugs blanked per extrusion, (4) follower block and condition, (5) length of crop removed, (6) number of I.D. defects, (7) % I.D. defects, (8) number of O.D. defects, (9) % O.D. defects, (10) as extruded O.D. - nominal, (11) % yield by weight-billet to shipped tube. The defect data was excerpted from MCW inspection report (Batch 62).

DISCUSSION OF RESULTS (continued)**DECLASSIFIED**

The analysis by results for the different follower block conditions is shown in Table III. For this tabulation, yield and crop length data from all extrusions under the same follower block condition in Table II, is averaged and the result listed. It can be seen by comparison that the pressed salt at 300°F produces essentially the same average yield as the standard graphite. However, the salt causes greater defective material on the rear. This necessitates an average additional crop of 10.4 inches and corresponds to the loss of approximately one slug per extrusion. This loss is offset cost wise by the comparison of \$.30 each for the pressed salt with \$7.90 each for the graphite.

The potential yield increase from a reduction in extruded O.D. is analyzed in Table IV. The % O.D. defects and % yield from Table II are averaged for all extrusions made at the same O.D. The results show that the 1.50" O.D. is near the optimum size, since the average % O.D. defects rises rapidly and the % yield lowers with a decrease in extruded O.D.

PROJECT NO. 10600
BB NUMBER 10600
EXTR. NO. U-21

TABLE I

EXTRUSION DATA
BRIDGEPORT BRASS CO.

ALUMINUM DIVISION - ADRIAN, MICH.

LUBRICATION

MANDREL Fiske 604
DIE Fiske 604
LINER Dag 170 - Old

PERSONNEL:
ENGINEER J. F. Puterbaugh
TECHNICIAN E. A. Shorthouse
PRESS OPER D. Smith

7.125
800°F
1150°

6
March 18, 1960
Normal 101

PAGE 1 OF 3 PAGES

HTG UNIT 800°F
TOOL OVEN TEMP

Tube
123's

SHAPE
CUSTOMER

ITEM NO.	BULLET NUMBER	BULLET WEIGHT	FURNACE TEMP OF	HEAT TIME HI-KN	TRANS TIME MIN	PRESSURE P S I	STRETCH/Run	EXTR TIME MIN	CALC "K"	VALU-TS	CALC SPEED	RPM "/MIN	EXT "/MIN	FI - IN	TOOL NUMBERS			REMARKS	Date
															CONE	DIE	HAND	Revs.	Faces
P1	91399B3	--	1200	2:28	1.4	2800	.50	.50	14.8	15"	15"	15"	15"	15"	C-162	D-329	M-106	4	0
1	91386B	433	1200	2:50	1.19	2500	1.26	1.26	17.4	13.2	13.2	13.2	13.2	13.2	"	"	"	4	3
2	91385B	487	1200	3:37	1.14	2600	1.74	1.74	18.0	13.7	13.7	13.7	13.7	13.7	"	"	"	4	3
3	91393B	495	1200	4:13	1.38	3200	1.39	1.39	16.9	15.8	15.8	15.8	15.8	15.8	"	D-330	"	3	5
4	91384T	438	1200	4:35	1.36	3150	1.13	1.13	16.6	13	13	13	13	13	"	"	"	3	5
5	91386T	447	1200	4:48	1.15	3200	1.11	1.11	16.6	12.4	12.4	12.4	12.4	12.4	"	"	II	3	5
6	91387T	490	1200	4:56	1.17	2700	1.27	1.27	14.2	17.7	17.7	17.7	17.7	17.7	"	D-226	II	3	5
7	91385T	489	1200	5:33	1.25	3350	2.73	2.73	18.0	12.7	12.7	12.7	12.7	12.7	"	"	II	3	5
8	91387B	490	1200	5:39	1.15	3400	1.30	1.30	17.4	11.6	11.6	11.6	11.6	11.6	"	"	II	3	5
9	91384B	496	1200	3:51	1.13	2200	1.19	1.19	13.7	11.6	11.6	11.6	11.6	11.6	"	D-329	II	3	5
P2	91399B2	--	1150	1:35	1.15	2600	.35	.35	12.1	14.7	14.7	14.7	14.7	14.7	"	"	II	3	5 2/3
10	91392T	495	1150	2:48	1.32	2800	1.25	1.25	12.7	15.0	15.0	15.0	15.0	15.0	"	"	II	3	5 2/3
11	91395B	440	1150	2:59	1.45	2850	1.22	1.22	12.7	15.0	15.0	15.0	15.0	15.0	"	"	II	3	5 2/3

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3/18/60

EXTRUSION DATA

PROJECT NO. A-800-1
 SB NUMBER 10600
 EXTR NO. U-21

TABLE I

BRIDGEPORT BRASS CO.
 ALUMINUM DIVISION - ADRIAN, MICH.

PRESS NO. 6

EXTR. DATE 3/18/60
 MATERIAL Normal 'U'
 SHAPE Tube
 CUSTOMER I&E's
 LINER NO 7.125
 LINER TEMP 800°F
 HTG UNIT 1150°F
 TOOL OVEN TEMP 800°F
 PERSONNEL
 ENGINEER J. F. Puterbaugh
 TECHNICIAN E. A. Shorthouse
 PRESS OPER D. Smith
 LUBRICATION
 MANDREL Fiske 604
 DIE Fiske 604
 LINER Dag 170 - Oil

PAGE 2 OF 3 PAGES																	
BILLET NO	BILLET NUMBER	BILLET WEIGHT	FURNACE TEMP OF	HEAT TIME	TRANS TIME	PRESSURE P S I	START/RUN	EXTR. TIME	CALC. "s"	VALUE-TS 1	CALC. SPEED FPM "/MIN	EXT. LENGTH FT - IN	TOOL NUMBERS		REMARKS	Rev. Faces	
													DIE	MAND			
12	91390B	496	1150	3:08	1.22	2750 2300	1.33	1.33	14.5 12.1	15"/	--	--	C-162	D-329	M-106 RF-111023	3	5 2/3
13	91390T	492	1150	3:23	1.36	2900 2500	1.34	1.34	15.3 13.2	"	--	--	"	D-330	III 1039	3	5 2/3
14	91388B	496	1150	3:31	1.17	2900 2500	1.41	1.41	15.3 13.2	"	--	--	"	"	III 1051	3	5 2/3
15	91395T	438	1150	3:37	1.18	2950 2150	1.14	1.14	15.5 12.9	"	--	--	"	"	III 1100	3	5 2/3
16	91388T	498	1150	3:46	1.19	2850 2500	1.35	1.35	15.0 13.2	"	--	--	"	"	III 1118	3	5 2/3
17	91389T	498	1150	4:44	1.18	3000 2600	1.28	1.28	15.8 13.7	"	--	--	"	"	III 1218	3	5 2/3
18	91397T	444	1150	2:59	1.07	2800 2400	1.07	1.07	14.7 12.6	"	--	--	"	"	III 1236	3	2/3
P3	91399B1	--	1150	2:50	1.15	2700 2400	.35	.35	14.2 12.6	"	--	--	"	D-226	IV 1250	3	4 2/3
19	91400B	494	1150	2:53	1.12	2600 2200	1.15	1.15	13.7 11.6	"	--	--	"	"	IV 1306	3	4 2/3
20	91392B	494	1150	2:46	1.28	3000 2600	1.32	1.32	15.8 13.7	"	--	--	"	"	IV 1313	3	4 2/3
21	91391T	451	1150	2:40	1.17	3200 2700	1.27	1.27	16.9 12.2	"	--	--	"	"	IV 1322	3	3 2/3
22	91389B	497	1150	2:37	1.17	3000 2500	1.18	1.18	15.8 13.2	"	--	--	"	D-329	IV 1330	3	3 2/3
23	91394B	496	1150	2:40	1.22	3300 2800	1.45	1.45	17.4 14.7	"	--	--	"	"	M106H -20 1347	6	

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PAGE 2 OF 3 PAGES

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BB NUMBER 10600
EXTR NO. U-21

TABLE I

6

3/18/60

7.125

NEW NO.

Normal 'U'

800°F

Tube

1150°F

I&E's

TOOL OVER TEMP

800°F

LUBRICATION

J. F. Puterbaugh

MAYOREL

Fiske 604

E. A. Shorthouse

DIE

Fiske 604

D. Smith

LINER

Dag 170 - Oil

PAGE 3 OF 3 PAGES

TOOL NUMBERS

Revs.

REMARKS
Faces

24	91391B	450	1150	3:00	1.30	3000	1.31	15.8	15"/	--	C- 162	D- 329	-20 1119	4
25	91396B	500	1150	3:05	1.66	3300	1.68	17.4	"	--	"	D- 330	1125	4
26	91397B	441	1150	2:53	1.30	3150	1.17	16.6	"	--	"	"	1132	4
27	91393T	491	1150	2:45	1.15	3200	1.26	16.9	"	--	"	"	1137	4

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[REDACTED]

FIGURE 3

EXPERIMENT - AS PERFORMED

U-21

Die - 1.50 FB - Salt 300°F Date - 3/16 Billets - 3 Date - 3/17 Billets - 1	Die - 1.48 FB - Salt 300°F Pulled From Furnace Date - 3/17 Billets - 1	Die - 1.52 FB - Salt 300°F Pulled From Furnace Date - 3/18 Billets - 3
	Die - 1.48 FB - Salt 400°F Date - 3/16 Billets - 1	
	Die - 1.48 FB - Graphite Date - 3/17 Billets - 3 Date - 3/18 Billets - 3	Die - 1.52 FB - Graphite Date - 3/16 Billets - 3
Die - 1.50 FB - Salt 300°F Pulled From Furnace Date - 3/17 Billets - 2	Die - 1.48 FB - Salt 400°F Pulled From Furnace Date - 3/16 Billets - 2	
Die - 1.50 FB - Salt Room Temp. Date - 3/18 Billets - 3	Die - 1.48 FB - Salt Room Temp. Date - 3/17 Billets - 2	

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TABLE II

JFP-17

U-21 CONSOLIDATED DATA BY BILLET NO.

Billet Number	Billet Wght.	Shpd. Extr. Wgt.	No. Slugs Blanked	Fol. Blk. & Condition	Lgth. of Cropped Tube (")	No. I.D. Defs.	% I.D. Defs.	No. O.D. Defs.	% O.D. Defs.	Nom. As-Ext. O.D.	% Yield Billet Tube
91384B	482.5	---	---	Graphite	(Identification Confused - Omit)					1.50	---
91384T	436	365.5	38	Salt 400	36	0	0	10	26.3	1.46	83.8
91385B	484	385.5	39	Salt 300	54	0	0	1	2.6	1.48	79.7
91385T	485	439	38	Graphite	--	0	0	0	0	1.50	90.5
91386B	431	377	38	Salt 300	28.5	2	5.3	3	7.9	1.48	87.5
91386T	443.5	371	35	Salt 400P	39	1	2.9	6	17.1	1.46	83.7
91387B	486.5	444	43	Graphite	--	3	7.0	0	0	1.50	91.3
91387T	486	410	41	Salt 400P	56	1	2.4	7	17.1	1.46	84.7
91388B	493	402	41	Salt 300P	57	2	4.9	0	0	1.46	81.5
91388T	493.5	416.5	42	Graphite	26.3	1	2.4	1	2.4	1.46	84.4
91389B	495	425	42	Salt R.T.	52	6	15.3	0	0	1.48	85.9
91389T	493.5	410	43	Graphite	30.8	5	11.6	6	14.0	1.46	83.1
91390B	492	426.5	41	Salt 300P	50	11	26.8	1	2.4	1.48	86.7
91390T	488.5	419	41	Salt R.T.	64.8	1	2.4	5	12.2	1.46	85.8
91391B	447.5	377	37	Salt R.T.	56.5	1	2.7	1	2.7	1.48	84.2
91391T	448.5	389	39	Salt 300	60.3	1	2.6	0	0	1.50	86.7
91392B	490	431	40	Salt 300	34.5	0	0	0	0	1.50	88.0
91392T	491.5	433	41	Salt 300	50.3	4	9.8	2	4.9	1.48	88.1
91393B	491	430	42	Salt 300	25	2	4.8	3	7.1	1.48	87.6
91393T	487	415	42	Graphite	39.5	9	21.4	7	16.7	1.46	85.2
91394B	493	---	---	Salt R.T.	(Identification Confused - Omit)					1.48	---
91395B	437.5	385	39	Salt 300P	51	3	7.7	14	35.9	1.48	88.0
91395T	434	375	43	Salt R.T.	52.5	4	9.3	3	7.0	1.46	86.4
91396B	495.5	412	42	Graphite	22.8	3	7.1	4	9.5	1.46	83.2
91397B	440	367	36	Graphite	37	32	88.9	2	5.6	1.46	83.4
91397T	441	401	38	Graphite	28.5	8	21.1	8	21.1	1.46	90.9
91400B	492.5	427	42	Salt 300P	54	0	0	0	0	1.50	86.7

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TABLE IIIANALYSIS OF FOLLOWER BLOCK CONDITIONSU-21

<u>Follower Block Condition</u>	<u>Number Billets</u>	<u>Avg. No. Slugs Per Extruder</u>	<u>Avg. % Yield Billet To Tube</u>	<u>Avg. Crop Length</u>
Graphite 800°F (Standard)	8	40.5	86.5	31.7
Pressed Salt (NaCl) Room Temperature	4	40.8	85.6	56.5
Pressed Salt (NaCl) 300°F - Pulled From Furnace	4	40.8	85.7	53.0
Pressed Salt (NaCl) 300°F	6	39.8	86.3	42.1
Pressed Salt (NaCl) 400°F - Pulled From Furnace	2	38	84.2	47.5
Pressed Salt (NaCl) 400°F	1	38	79.7	36.0

NOTE: Pulled - means pulled from pre-heat furnace at same time as billet and allowed to cool at room temperature for length of time necessary to transfer and load the billet into the press.

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TABLE IV
ANALYSIS OF O.D. REDUCTION
U-21

<u>Die Size</u> <u>(Nominal Extruded</u> <u>O.D.)</u>	<u>Number</u> <u>Billets</u>	<u>Avg.</u> <u>% O.D.</u> <u>Defects</u>	<u>Avg.</u> <u>% Yield</u> <u>Billet</u> <u>to Tube</u>	<u>Avg. No.</u> <u>Slugs</u> <u>Per</u> <u>Extr.</u>
1.52" (1.50")	5	0	88.6	40.4
1.50" (1.48")	8	(1) 3.9	86.0	39.9
1.48" (1.46")	12	12.4	84.7	40.2

NOTE:

(1) Omitted 1 35.9% As Extreme

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CONCLUSIONS

1. Pressed salt follower blocks can economically replace graphite providing the pre-heat temperature is adjusted to compensate for the difference in relative fluidity of the two materials under extrusion pressures.

2. The present die size - 1.52" (extrusion size - 1.50") is optimum for producing the least O.D. defects.

3. The yield with graphite follower blocks is reduced from the yield with a high yield dummy block and no follower. The original work on graphite follower blocks was done with a solid rod product and it is thought that the difference between that product and the thick-walled I&E tubing could produce the lowered yield due to increased piping. Another extrusion of I&E tubing will be made without follower blocks to determine if the above is true.

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