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ECONOMICS OF REUSABLE CRUCIBLES

INTRODUCTION

A high expense item in the operation of the button line has been the RS-6 crucible which can be used only once. The 234-5 Research and Development Laboratory has done some preliminary development on a reusable crucible. Before continuing their program, they have requested that an economic study be made to determine what potential savings could be realized if RS-6 were replaced with a reusable crucible.

SUMMARY AND CONCLUSIONS

For the purpose of this study, the costs involved were broken down into three areas: Button line costs, Recuplex costs, and Conversion costs. Button line costs include initial crucible costs, operational handling and radiation factors, and other material savings. Recuplex costs cover the effect the elimination of crucible fragments would have on the recovery operation. Conversion cost is an estimate of the expense required to convert the present button line to use a reusable crucible.

The results of the study are very favorable and the total possible savings appear to be high enough to write off the cost of conversion of the button line to use the reusable crucible in one year. Of course, the available savings are dependent upon the purchase price of the reusable crucible and the number of firings that can be made with it. To write the conversion off in one year, the purchase cost per firing of the crucible must be equal to or less than \$20. The reason that this figure is higher than might be expected is due to the many additional costs connected with the RS-6 crucible that the reusable crucible would eliminate. The results of this study are discussed more completely in the last or Conclusion section of this report.

There are several hidden benefits of a reusable crucible that are hard to put a price tag on. One of these would be a decrease in the crucible fragments backlog in Recuplex. Storage area now taken up by fragments could be used for other purposes.

DISCUSSION

Button Line Costs

The areas considered in this section are initial crucible costs, possible radiation and operational time savings, and other material savings.

The RS-6 crucible now in use costs \$1734 per 100 and the actual number of crucibles used from September, 1960, through August, 1961, was 3073. During this same period, the number of crucibles fired was 2732. The difference in the two

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numbers is attributed to 11% breakage which is assumed would not be a problem with a reusable crucible. Since production is not expected to change appreciably during next year, the 2732 figure is used throughout this report.

Cost of Present Crucible

$$(3073 \text{ crucibles/year}) (\$17.34/\text{crucible}) = \$53,300/\text{year}$$

The present operational time and radiation factors in the button line area were studied. The elimination of crucible and sand from the sacking out procedure would cut the time required to do the job by no more than two minutes per sack-out or 16 minutes per shift. The time savings would approach an hour per shift if it were possible to mix the fragments from several crucibles together in one can, but accountability requires that each crucible be canned and processed separately. Therefore, the time savings in this area are too small to affect costs. The time required to load sand and crucibles into hood would also be eliminated, but again, this amounts to no more than 15 minutes per shift.

The canning and sacking out of crucible fragments requires 5.9 minutes of contact with the cans of material per operation. The close rate of the can is rated at 4.2 mr per hour. Assuming a maximum of eight firings per shift, an operator may receive 3.3 mr per shift. These savings are also too low to affect operational costs. Additional savings are realized in other materials required by the present RS-6 crucible. It is assumed that a reusable crucible would not require the magnesium oxide sand now being used, and the elimination of the sand and crucible fragments from the canning and sack-out operation cuts the number of cans required from two to one per crucible. The sand and can savings are based on the actual sand consumed and buttons fired for the period of September, 1960, through August, 1961.

Cost of Sand Used

$$(4569 \text{ lbs/year}) (\$97/100 \text{ lbs}) = \$4440/\text{year}$$

Potential Can Savings

$$(2732 \text{ firings/year}) (1 \text{ can saved/firing}) (\$0.225/\text{can}) = \$615/\text{year}$$

The total button line cost reduction is consolidated below:

Crucible Cost	\$53,300
Sand Cost	4,440
Can Cost	<u>615</u>
TOTAL Button Line Cost Reduction	\$58,355

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Recuplex Costs

As a basis for computing the cost factors in the recovery operation, Research and Engineering was asked what the effect would be if the crucible fragments and sand they normally received mixed with slag, were eliminated from the cans of slag received from the button line. To predict the results as close as possible, a flow sheet was prepared in which the magnesium oxide, which the sand and crucible fragments contribute, was absent. The estimated flow sheet for the new continuous dissolver showed that while the process with MgO required 336 liters of chemicals to dissolve $5\frac{1}{2}$ crucibles, only 193 liters of chemicals would be required to dissolve the $5\frac{1}{2}$ crucibles without the MgO present. The estimated flow sheet also indicated that a greater amount of slag and oxides could be processed in a given period of time. Therefore, both a materials savings and a time savings are created in the continuous dissolver when the costs are distributed on a per unit of Pu basis.

It should be noted here that at the time this report is published, the continuous dissolver will not be fully operational. The batch dissolver now being used would have approximately the same material savings as the continuous dissolver, but for criticality reasons, no time savings would be made. Therefore, the savings presented here are based on the following assumptions:

1. By the time a reusable crucible is ready for use, the continuous dissolver will be in full operation.
2. The solvent extraction columns will be able to handle all the B-feed the continuous dissolver can generate.

The following table is presented to demonstrate the potential time savings in the dissolution area.

Process	Approximate Pu Content of Solution Generated	Approximate Quantity of Solution Generated in Six Hours
Present Batch Dissolver with MgO in Solution	0.8 gram/liter	300 Liters
New Continuous Dissolver with MgO in Solution	2. gram/liter	400 Liters
New Continuous Dissolver without MgO in Solution	2. gram/liter	500 Liters

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Both the batch dissolver as well as the continuous dissolver are shown in the table to point out that the time savings that would be created by the elimination of MgO from the dissolution process have not been confused with the time and concentration savings that will be created by the continuous dissolver.

When computing the dissolution savings, the costs charged to Recuplex were taken for the first six months of calendar year 1961, and distributed in accordance with HW-64295. All the slag and crucible fragments processed through Recuplex during the January through June, 1961, period were generated on the button line. Therefore, no calculations were necessary to factor out crucible fragments generated in other areas.

There is a possibility of high cost savings in the solvent extraction process, but they cannot be verified without test runs. Presently, there are two flow sheets being used for the solvent extraction columns. The "X" flow sheet uses the normal B-feed generated in the slag and crucible dissolvers. The "Y" flow sheet requires a synthetic B-feed to be made up. If the MgO is removed from the normal B-feed, it may be possible to use it in the "Y" flow sheet as well as the "X" flow sheet and eliminate the need for synthetic B-feed.

If this is true, an annual savings from \$50,000 to \$100,000 would be realized. Since it looks as if the conversion of the button line to a reusable crucible can be justified without these additional savings, a test run did not seem necessary at this time.

Recuplex Cost Reductions

Dissolution Material	\$1.65/crucible
Dissolution Time	<u>6.53/crucible</u>
TOTAL Reductions	\$8.18/crucible

Annual Cost Reductions = (2732 firings/year) (\$8.18/firing) = \$22,400

An additional cost that a reusable crucible would generate is that of leaching the expended crucible. Leaching costs are difficult to estimate since very few actual operating cost records have been accumulated in this area. Therefore, the leaching cost has been based on the estimate for the new leaching facility in HW-70589, which is \$137/batch. It is assumed that this facility could handle three crucibles per batch. Therefore, the cost per crucible would be \$45.67.

Additional Recuplex Leaching Costs

(\$45.67/crucibles expended) (2732 firing/year) ÷ (firing/crucible) = \$/year

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Conversion Costs

The Process Design Engineering Operation's Finished Products section was requested to assist in estimating the probable cost of converting the button line to use a reusable crucible. The cost estimate is based on the following assumptions:

1. The new crucible will require a change in only one process on the button line and that process is the crushing of the RS-6 crucible within the pressure vessel in Hood 16.
2. The existing Hood 16 will be adapted to house the new equipment.
3. The new equipment involved will consist of a stationary core drill which will drill the slag loose from the reusable crucible's walls without damaging the crucible. The crucible will be raised and lowered on the existing hydraulic ram to actuate the drilling.
4. The slag core and button will be dumped from the crucible in the usual manner.
5. New pressure vessels will be required to adapt the reusable crucible to existing equipment.
6. The new equipment will be proto-typed in Maintenance Hood 18.

The cost estimate is itemized below:

Equipment Cost:	Core drill	\$ 4,000
	Install and move proto-type	1,500
Installation Cost:	Remove existing equipment	1,000
	Install new equipment	1,000
Associated Equipment Cost:	Vacuum system	3,500
	New pressure vessels	6,000
Other Costs:	Design	5,000
	Contingency	<u>3,000</u>
TOTAL COST		\$25,000

Conclusions

All the potential cost reductions and costs are itemized on following page:

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Potential Cost Reductions

Potential button line cost reduction	\$58,355/year
Potential Recuplex cost reduction	22,400/year
TOTAL Cost Reduction	\$80,755/year

Potential Costs of Operating With New Method

Leaching Costs - $(45.67)(2732) = \$/\text{yr. Total}$
Reusable Crucible Costs - $(2732 \text{ firings/Year}) (\text{Cost of crucible firings/crucible})$

Conversion Costs

Conversion of Button Line Cost - \$25,000

The Potential Annual Savings is the difference between the Potential Costs Reductions and Potential Costs. If $X = \text{firings per crucible}$, and $Y = \text{cost of crucibles}$, and the buttons fired per year = 2732, then the potential annual savings can be expressed by the following equation:

<u>Potential Cost Reductions</u>		<u>Potential Costs</u>	
(Potential Button Line) (Cost Reduction)	(Potential Recuplex) (Cost Reduction)	(Potential New) (Leaching Cost)	(Potential Annual) (Cost of Reusable) (Crucible)
$58,355 + 22,400$		$-(45.67)(2732)$	$-\frac{2732Y}{X}$
$80,755$		X	X

Since the potential cost reduction is \$80,755, and estimated cost of converting the button line to use a reusable crucible is only \$25,000, it is apparent that the conversion cost can probably be written off in one year. To gain a measurement to judge a proposed crucible against, the break even cost will be computed assuming a one year write off of the conversion cost. To do this, the annual savings will be set equal to the conversion cost.

$$\text{Annual Savings} = \text{Conversion Cost} \quad 25,000 = 80,755 - \frac{(45.67)(2732)}{X} - \frac{2732Y}{X}$$

Solving this equation for Y, or crucible cost, in terms of X, firings per crucible, we find that

$$Y = 20.4X - 45.67$$

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This is a straight line equation with a slope of 20.4. The slope represents the break even cost per firing of a crucible. In other words, if a proposed crucible has a purchase cost of \$20.40 or less per firing, the cost of converting the button line to use it can be charged off in one year.

To demonstrate these results, the following example is presented:

Assume the proposed crucible purchase cost will be \$50 and it will be good for ten firings. Then the cost per firing will be $\frac{\$50}{10} = \5 or well below the break even point of \$20.40. The annual savings would be:

$$\begin{aligned}\text{Annual Savings} &= 80,755 - \frac{(45.67)(2732)}{10} - \frac{(2732)(50)}{10} \\ &= 80,755 - 12,500 - 13,660 \\ &= \$54,595\end{aligned}$$

In this case, the conversion cost of \$25,000 could be charged off in one year and still leave approximately \$25,000 in savings that year.

It should be remembered at this point that several assumptions are made in arriving at the final costs. Some of the most important are the assumptions concerning the crucible and they are listed as follows:

1. Breakage of the crucible before firing will be negligible.
2. No sand will be used to support the crucible in the pressure vessel.
3. The crucible will be cleaned by leaching before being discarded.
4. No other Recuplex throughput will be generated by the process other than the slag and crucible leachings.

If a radical change in thought is made concerning the probable design of the reusable crucible, the report should be checked to see if the original assumptions still hold true before applying the cost estimates.

ACKNOWLEDGEMENT

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