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MOBIL RESEARCH AND DEVELOPMENT CORPORATION

RESEARCH DEPARTMENT

TECHNICAL MEMORANDUM NO. 67-32

USE OF CORRECTIVE INSERTS TO IMPROVE CHARACTERISTICS OF THE 100 TON SHALE STORAGE BINS

ANVIL POINTS OIL SHALE RESEARCH CENTER

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The primary object of the Anvil Points Oil Shale Research Center TECHNICAL MEMORANDUM is to advise authorized personnel employed by the Participating Parties[1] that various activities are in progress or that certain significant data have been obtained within the Research Center.

These TECHNICAL MEMORANDA have been prepared to provide rapid, on-the-spot reporting of research currently in progress at Anvil Points. The conclusions drawn by project personnel are tentative and may be subject to change as work progresses. The TECHNICAL MEMORANDA have not been edited in detail.

[1] Mobil Research and Development Corporation, Project Manager

Continental Oil Company
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USE OF CORRECTIVE INSERTS TO IMPROVE CHARACTERISTICS OF THE 100 TON SHALE STORAGE BINS

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USE OF CORRECTIVE INSERTS TO IMPROVE CHARACTERISTICS OF THE 100 TON SHALE STORAGE BINS

I. INTRODUCTION

The general shape and geometry of the three 100 ton storage bins used for raw shale retort feed resulted in extremely poor shale flow in the bins during Stage I of the Anvil Points Research Program. The bins are 18 feet in diameter with a vertical wall height of 10 feet and a 45 degree conical bottom.

The shale flow pattern through the bins exhibited ratholing in the center while the walls remained static. As the bin was emptied, the rathole deepened to the point that the angle of repose of the static shale on the walls was exceeded. The shale on the walls would then collapse toward the center of the bin, resulting in a severe particle size segregation condition. Initially material withdrawn from the bin would be oversize, and as the drawdown of the bin continued, the quantity of fines in the material being withdrawn would increase.

In order that these bins would be satisfactory for use as the primary surge vessels charging raw shale to Retort No. 3, it was necessary to improve their flow characteristics and to alleviate particle size segregation.

Height limitations and available storage capacity of the vessel ruled out the possibility of utilizing the developed "know how" of multipipe single level or the multilevel slot drawoff systems. Furthermore, the uniformity of flow that can be developed with either of these systems was not necessary in this vessel since it was believed that a "live" bin would reduce particle segregation to tolerable limits.

The use of baffle inserts was the approach that appeared to be the most promising in view of the limitations imposed. With little experience and knowledge in the use of inserts as flow correcting devices it was deemed advantageous to explore the subject in a scale model.

II. SUMMARY AND CONCLUSIONS

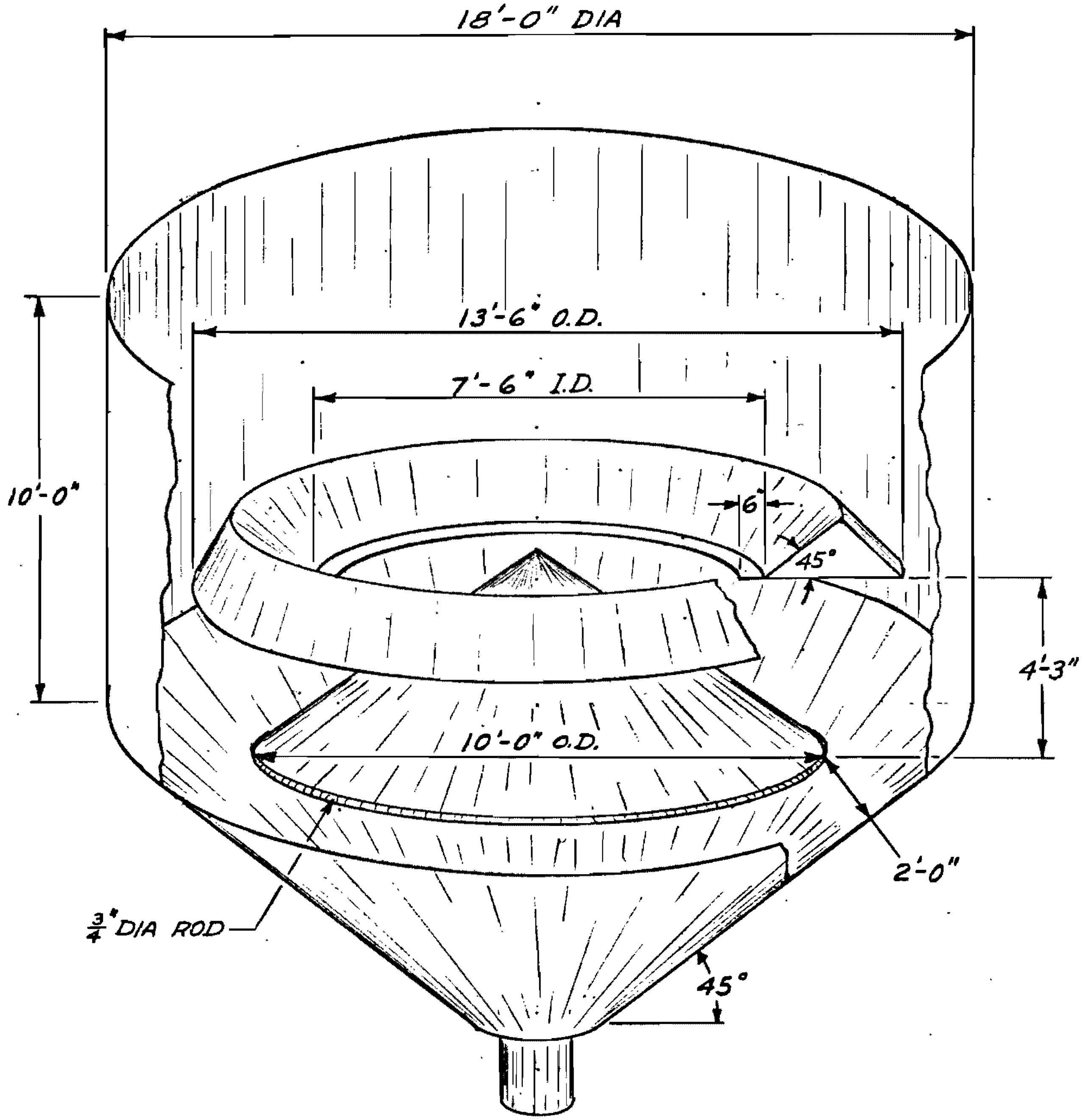
The 100 ton storage bins were modified to conform to the developments indicated by the scale model studies. Figure 1 depicts the completed installation after the final trim adjustments were made to produce the satisfactory shale flow pattern for the shale size ranges to be processed.

The scale model successfully predicted the size and position of the center insert and the supplemental ring that proportioned the flow between center and walls. Final flow adjustments to the full scale installation were necessary to compensate for the lack of calming height in the bin outlets to the vibratory feeders and the difference of flow characteristics between the 1/4 to 1 inch and the 1 to 2 1/2 inch shale sizes.

As a result of this experience, it was concluded that the use of corrective inserts is not a particularly attractive way of obtaining uniform flow in a vessel. The geometry and physical positioning of an insert will only be applicable to a particular bin and material of prescribed size range. Insert assemblies can be extensive to achieve the desired effect (Figure 1). Flow patterns are sensitive to outlet conditions. Adequate calming height in the outlet nozzle must be provided to make the insert effective.

However, if flow correcting inserts must be designed for a given situation, scale models are most valuable in guiding the design of insert installations. It must be cautioned that the scaled down particles used in the model may have different shape characteristics than their prototypes and thus affect the results in the model. Extreme care must be exercised in construction since small dimensional changes produce large effects both in the model and the unit. Success or failure of the insert installation depends on absolutely correct sizing and positioning of the assembly. It must be emphasized that although the model studies did predict the dimensioning and positioning of the insert assembly, field adjustment to the installation was necessary to achieve the uniformity of flow required.

FIGURE 1



INTERNALS
100 TON BINS

III. DETAILED DISCUSSION

In light of the extreme difficulty of applying a conventional drawoff system because of excessive height requirements and consequent reduction of storage capacity of the bins, the use of conical baffles to improve the shale flow in the 100 ton bins was chosen. The problem was attacked by construction of a 1/12th-scale plexiglass model of the bin to permit fast exploration of various arrangements of inserts in a trial and error procedure. Shale was screened to the appropriate scaled down size ranges to be investigated, 1/4 to 1 inch and 1 to 2 1/2 inch. The one design criteria that a minimum clearance between insert members and bin walls of 2 feet for adequate shale flow was also established.

It was quickly established in the model that a center line insert of at least 10 feet in diameter was necessary to establish flow at the vessel walls. On the basis of established flow patterns for the shale sizes it had been expected that shale flow at the walls would be achieved with a 6 foot diameter insert.

The center baffle established shale movement over the entire bin surface; however, it was then necessary to achieve a uniformity of shale velocity through the open area section surrounding the center insert. The center portion had to be slowed while the outer periphery of the bin was speeded up. This was achieved with a "donut-ring" positioned around the center line of the bin. Its vertical placement was in accordance with the 2 foot shale flow clearance limit. It was found that the inside and outside diameters of this ring were very critical as small changes resulted in large changes in flow characteristics. The initial design that was recommended and installed in the three 100 ton bins called for a 10 foot diameter 45 degree conical insert with a 3 foot wide donut ring with an inside diameter of 7 1/2 feet and an outside diameter of 13 1/2 feet. It was realized that due to the critical nature of the ring dimensions, further modification would be necessary in the full scale installation.

Continued work in the scale model with the shale size ranges showed that an additional modification was required to reduce the flow in the center section of the bin. This was confirmed by observations of the flow pattern of the full scale bin with 1 to 2 1/2 inch shale size. The model work predicted that a one foot diameter reduction to the inside diameter of the ring would be required to adjust the flow. This modification was then incorporated in the bins.

The bin observations also had revealed that the flow characteristics of one bin were substantially different from the other two. In that bin the pattern was unsymmetrical, fast flow in one wall area and very slow or no flow on the opposite wall.

The flow in this bin was found to be influenced by the syntron feeder on the outlet. This effect had been noted previously when development work on the single level multipipe drawoff system was being conducted in the 60 ton storage bins and was caused by lack of calming height in the outlet. Baffling the outlet to enforce more flow from the center and back of the nozzle was the solution chosen for this problem.

Continued observation of shale flow patterns for the modified assembly revealed acceptable flow for the 1 to 2 1/2 inch and 1/4 to 2 1/2 inch shale sizes. However, for the small shale, 1/4 to 1 inch, there was still a tendency for faster flow in the center. This confirmed the observations in the scale model.

It had been noted in the model work that a lip or ledge at the base of the center cone had a marked effect on the flow pattern of the small particles. Further experimental work showed that a 1/16 inch round bar at the base of the cone in the model reduced the tendency of the small shale to rathole down the center to acceptable limits and did not deleteriously affect the shale flow pattern for the larger sizes. This modification was incorporated in the full scale bin assembly.

Observation of the flow patterns in the bins with all three shale size ranges were then made and it was found that acceptable flow patterns had been achieved.

It should be pointed out that the 45 degree angle for the center cone and conical cover on the ring was chosen to permit self-cleaning as this angle is greater than the "angle of repose." Over the choice of a steeper angle, it reduced the height of the assembly, thus increasing the capacity of the bin. Also, as had been noted from studies on the mass flow bin concept, the steeper the angle of the bottom, the more the flow at the walls is increased. Thus, a center insert with a steep angle, although possibly promoting some flow at the wall, would not be predicted to alleviate center ratholing.

The use of inserts to correct flow patterns in existing installations is feasible but not attractive because of the difficulty in predicting proper design. Small scale models provide a most valuable tool for the study of insert sizing and positioning, and the results are reliable. Caution must be exercised with the model due to its sensitivity to dimensional correctness, geometric alignment, and true plane orientation.

An unedited motion picture showing the evolutionary development of the bin inserts using the scale model is being retained in the Project file.