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STATUS REPORT - FUEL ELEMENT MACHINING

February 12, 1958

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INTRODUCTION

This report summarizes the design and development work completed since May, 1957; the current status of fuel element machining problems, and the plans for future modifications to improve machining techniques. Specific items of completed work which are summarized in other reports will not be included. For detailed information concerning existing tooling systems, general design criteria or equipment capabilities the following reports are available:

1. HW-50372 - Status Report, Fuel Element Machining, May 31, 1957.
2. HW-51402 - Design Completion Report, Blunt-Nose Tru-Line Tooling System, July 17, 1957.
3. HW-53351 - Design Completion Report, Interlocking Contour Tooling System, October 25, 1957.
4. HW-52996 - Installation Completion Report, Blunt-Nose Tru-Line Tooling System, October 11, 1957.

I. SUMMARY OF COMPLETED WORK (Ref: 1, 2, 3 & 4)

Since May, 1957, several tooling systems were designed and tested, a new Acme-Gridley lathe installed, and a modified load-unload mechanism designed and tested.

A. Tooling Systems

A tooling system to face the blunt-nose tru-line fuel element has been in production operation since September, 1957. This system faces the cap end contour in one machine at piece rates to 9.0 pcs/minute. Included in this tooling system was a prototype tool setup system for pre-set quick change tooling.

Interim tooling systems for base and cap end facing of I & E fuel elements were installed on Acme-Gridley lathes 3 & 4. These systems are similar to those used on the hand-operated machines with form tools used for contouring. Although these systems are operating at present production rates, problems with can wall burr, chip control and tool change seriously limit their use for continuous production.

The interlocking contour tool system (Ref. 3) was designed to produce a standard contour on either solid or I & E fuel elements. With this standard contour the types of tools required will be reduced, one basic tooling system will face all cap ends of all contoured pieces and form tool grinding will be reduced to a minimum. This tooling system will include equipment for pre-setting all tools which produce a finished surface. Thorough production testing of the pre-setting equipment will be required. Ref. III-A.

B. Installation of Acme-Gridley Lathe #4

Acme-Gridley Lathe #4 was installed and placed in operation during December, 1957. Although the basic machine is identical to those already in use, two important features have been added:

1. Chucking and spindle stopping can be done on spindles 2, 3, 4, 5 and 6 either singly or in multiple combinations.
2. A spindle can be stopped in one position and indexed to the next position without rotating in between.

The machine is operated with the load and unload functions taking place at different spindle positions. Although production rates are presently limited by the tooling system a man-motion synthesis of this operation has shown that higher production rates can be attained.

C. Mechanical Load-Unload System

A prototype mechanical load-unload system was designed for operation on Lathe #4. Two spindle positions are used, loading at position #3 and unloading at position #2. Only preliminary testing of the load portion of this mechanism has been completed, but results were very good. The unload mechanism has been used for production but is considered unsatisfactory for full automatic operation. Although more prototype evaluation would be beneficial it may be necessary to initiate final design of production equipment before this machine can be released from production for further test work.

II. CURRENT FACING PROBLEMS (Ref 1)

Although the general problem of successfully machining 2S aluminum clad contoured pieces at high production rates has been overcome, there are some specific problems which will require further design and development work. In general these problems are; chip control, can wall burr, tool change and dimension conformance, operating reliability and product mix.

A. Chip Control

The basic problem of providing a disposable chip form has been solved. By proper application of tool form it is possible to handle chips quite easily with minimum machine time loss. However, chip shields and guards are required to reduce damage to the work piece during machining. It has been found that effective shielding is best designed by closely observing the machining operation under sustained production conditions. By continuous observation it is possible to develop simple shields which adequately protect the work piece without cluttering up the working area. The best chip shielding has been done by personnel in operations and maintenance engineering who are closely associated with all operating conditions encountered.

B. Can Wall Burr (Ref 1)

This particular problem causes a large share of the facing and welding rejects which are, or should be, charged to the facing operation. During the facing operation a small wire edge collar is generated around a circumference of the can. This burr varies in size in relation to certain variables in the facing operation. It is always present to some degree, and due to the nature of the materials involved and the quantities of material produced it can only be COMPLETELY ELIMINATED by exotic and expensive machining techniques or by operating existing equipment at excessively high spindle speeds and extremely low feed rates.

However, operating experience has shown that the burr condition can be controlled to the extent that subsequent operations are not affected by its presence. At the present time rollers are used to reduce the burr. This is an interim solution.

Three primary variables affect the degree of burring encountered in facing:

• 1. Tool Design

The amount of burr can be decreased by increasing the back relief angle of the tool producing the finished surface. At the present time the primary problem with can wall burr is encountered on cap end facing of I & E fuel elements. The tool producing the burr condition has a back relief angle of 45°. In the interlocking contour tool system this surface will be finished with a single point tool with a back relief angle of 64°.

2. Tool Condition

As a cutting tool wears the edge becomes dull and buildup starts. Under these conditions the cutting force exerted by the tool increases and the deformation of the metal being cut increases. To minimize the effect of this condition it is necessary to maintain a sharp cutting edge on all tools generating finished surfaces. This can best be done by (a) reducing the amount of material removed by finish tools and, (b) establishing tool change frequencies such that excessive dulling does not occur.

Part (a) is being given consideration in the interlocking contour tooling system (Ref 3). Part (b) will be put into effect when the interchangeability of preset tools has been established.

3. Feed Rate

The degree of edge burr can be controlled to some extent by varying the feed rate of the tool. Further development along this line will be done in the near future. See III-A.

C. Tool Change and Dimension Conformance

As individual machine capacities increase it is necessary to reduce tool change time to retain operating efficiency. A preset tooling system has been designed which will reduce machine down time. With successful operation of this system a study of economic tool life will be necessary. (See III-B)

D. Operating Reliability

The operating efficiency and production capacity of these machines have been greatly increased since January 1957. However, as production levels and product mix complexities increase, it becomes increasingly important to stress reliability at this operation. At the present time Maintenance Engineering is contributing to component reliability by examining closely all trouble spots as they occur. Design emphasis on all new equipment will be placed on simplicity in parts and operations and reliability of components.

E. Product Mix

There are many products being produced in the fuel element fabrication facilities. In these machines there are three basic changes which must be made to run fuel elements of various types.

1. Tool Change (contour)

To face fuel elements with various types of contours it is necessary to change entire tool setups.

This problem will be eliminated with the adoption of standard contour fuel elements.

2. Collet Change (diameter)

Collet pad inserts have been designed which reduces diameter change over time to two hours.

3. Spindle Rod Change (length)

A change in lengths requires that collet push rods be extended and adjusted. This adjustment can be eliminated under certain operating conditions. (See III-C).

III. PROPOSED DEVELOPMENT-DESIGN WORK - FUEL ELEMENT MACHINING

The following problems are those which should receive primary attention to improve the fuel element facing operation.

A. Standard Fuel Element Contour

A fuel element contour was designed and tested which meets all reactor requirements for aligning and interlocking fuel elements in reactor process tubes. If this contour is used on all fuel elements tool changing will be practically eliminated. Tooling costs using the interlocking contour (Ref. 3) are greatly reduced because:

1. One contour tool replaces all form tools presently required.
2. Form tool life is increased 2-4 times.
3. Tool changeover time is eliminated.
4. Gaging, welding and other operations are simplified.

Adoption of this contour will reduce production costs and eliminate many product mix problems.

B. Can Wall Burr

It is the writer's opinion that can wall burr can be reduced to the point that it will have no effect on finished fuel element quality if the following approach is taken.

1. Install interlocking contour tooling system and evaluate burring problem. If problem still exists:
  - a) Review tooling applications to determine if optimum situation has been attained.
  - b) Determine correlation between tool-life and burr condition, if possible.

2. Revise end tool slide cam to produce fine feed rate for last .020 to .040" of tool slide travel. Re-evaluate facing type finishing cut.
3. Re-cam machines to reach minimum feed rate conditions.
4. Increase spindle RPM.

Information available from prototype work completed to date indicates this problem should be resolved by above step 2.

C. Economic Tool Life

The interlocking contour tooling system uses four tools to produce a contoured fuel element. These tools are cheap to fabricate and have long production life in comparison to form tool setups used in the past. From observation of tool change procedures presently used, it is evident that tools are not changed frequently enough to keep problems of can wall burr and dimension control under proper control. With simple, regrindable tool shapes and reliable presetting and quick-change features it is advisable to re-evaluate tool life philosophy and establish tool life ranges. Since a tool can be reground several times for the fabrication cost of a new tool, and since scrap material at this work station represents a loss of product, a re-evaluation of tool change practices must be made.

D. Length Changeover

With the change of load - unload on machine #4 it has become possible to eliminate the changeover time presently associated with various lengths of pieces. With the addition of one air cylinder, accumulator and pressure relief valve, it will be possible to face 4, 6 and 8 in. fuel elements simultaneously, providing that the same depth of cut and contour is required on each piece. This change will also eliminate the push rod springs presently used inside the spindle assembly.

This same feature will be incorporated on all machines when new chucking mechanisms are installed. If desired by operations an interim system can be installed on these machines to reduce changeover problems currently encountered.

The design of equipment for automatic length compensation on machine #4 will be complete by 3-15-58. Accompanying this design will be recommended changes in component design to derive maximum benefit from this feature.

E. Mechanical Load-Unload

Detail design of a mechanical load-unload system will be initiated during March, 1958. The following changes to basic machine design will be required.

1. Machines 1, 2 and 3 will be converted from single station load-unload to two station load-unload.
2. Control circuitry for all machines (air and electrical) will be revised to provide automatic, semi-automatic and hand-operating options. All extraneous valves, piping and wiring will be eliminated and revised (reproducible) drawings will be issued.

The following new pieces of equipment will be designed in the following sequence:

<u>Equipment</u>	<u>Estimated Design Completion</u>
1. Load Cradle	4-1-58
2. Unloader	4-15-58
3. Loader	5-15-58
4. Input Feeder	6-1-58

F. Stamping

Several inquiries have been made concerning stamping fuel elements in the lathe. This is not considered as a practical solution to the stamping problem. Although it may be physically possible to accomplish the operation, considerable study of alternate solutions should be made before selecting this approach.

SUMMARY

In the past year, developments such as the standard contour and interchangeable tooling have brightened the prospects of reducing machining problems. With continued emphasis on (1) standardization of contours and components (2) tool systems which use simple tool shapes (3) decreasing equipment change requirements with further equipment design and proper product scheduling and (4) economic evaluation of tooling practices, it will be possible to realize further savings in this operation.

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