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TELEROBOT TOOL MAINTENANCE USING MASTER-SLAVE MANIPULATORS (U)

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DISCLAIMER

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SUMMARY

The Savannah River Site (SRS) will process large bulky transuranic (TRU) waste items with a robotic gantry manipulator. The Savannah River Technology Center (SRTC) built a TRU Waste Test Facility (TWTF) to demonstrate this concept. The test robot uses several tools (i.e. plasma torch, chain saw, and gripper) to open, size reduce, and repackage simulated waste items. Waste processing campaigns in the TWTF show the various robot tools require periodic maintenance, such as replacing the torch tip and replacing saw blades. The primary objectives of this test were to determine if standard master-slave manipulators (MSMs) can complete remote robot tool maintenance, and if so, how long does the maintenance take. Test results show that MSMs completed 5 of 8 tool maintenance tasks attempted, and each task took 15 minutes or less. The three tasks that couldn't be completed involved specially designed tools, and these tools could be redesigned to allow remote MSM maintenance. MSMs can complete robot tool maintenance in a reasonable amount of time. This conclusion supports the SRS philosophy of remotely processing large bulky TRU waste items using a robotic gantry manipulator.

BACKGROUND

The SRS temporarily stores TRU waste in large steel boxes, concrete culverts, and galvanized drums on concrete pads in the Burial Grounds. This waste must be opened, processed, and repackaged before it can be sent to the Waste Isolation Pilot Plant (WIPP) for final disposal. The SRS will process TRU waste for permanent disposal in the proposed High Activity TRU Facility (HATF). The HATF will use a large cell and a robotic manipulator to process large bulky TRU waste items, and the SRTC built the TWTF at TNX to demonstrate this concept. The test manipulator, or telerobot, uses several tools to process simulated waste items and these tools need periodic maintenance. Telerobot tools include a plasma arc torch, a chain saw, a circular saw, a parallel jaw gripper, and a plastic cutting device.

DISCUSSION

The following paragraphs describe the test objectives, test equipment, telerobot tools, test preparation, and test procedure.

Objectives

The main test objectives were to 1) determine if MSMs could complete telerobot tool maintenance, and 2) determine the time required to complete maintenance tasks.

Test Equipment

The equipment used in this test included two MSMs, various hand tools, and a work table. The MSMs used were a Central Research Laboratory (CRL) System 50 manipulator and a CRL Model 8 manipulator. The System 50 is a newer heavy duty manipulator while the Model 8 is an older medium duty manipulator. A stand holds both manipulators and it contains a window for operators to view the slave portion of the manipulators. The hand tools included several allen wrenches, screwdriver style wrench, screwdriver, and socket wrench. TNX maintenance added a pivoting handle to the socket wrench so the MSMs could better hold the wrench during rotational movements (see Figure 1). This is needed because the MSM gripper couldn't efficiently hold the handle while moving in an arc. The work table is 4' x 8' with 8" walls around the sides to prevent items from falling off the table and the table is approximately as high as the operator's waist.

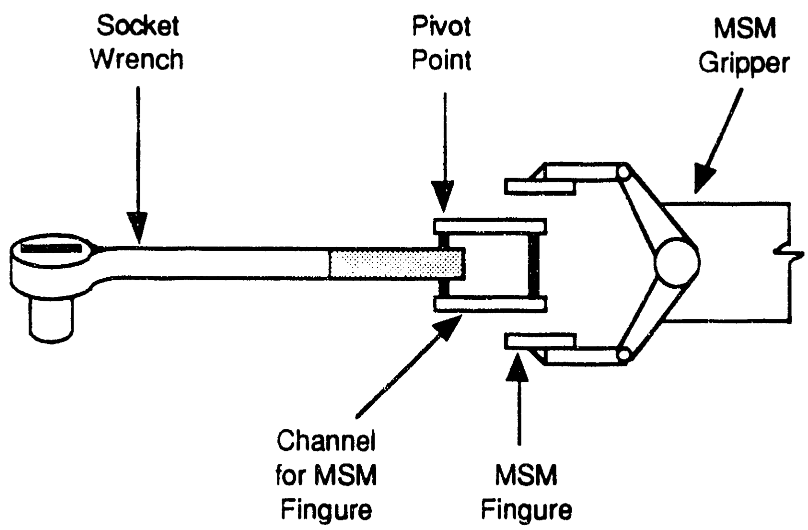

Figure 1 - Modified Socket Wrench

Telerobot Tools

The telerobot tools used in this test are a plasma arc torch, chain saw, circular saw, parallel jaw gripper, and plastic cutting device. The plasma torch is a Thermal Dynamics PAK 45 cutting torch. A plasma forms between the torch electrode and the metal waste item. The plasma heat melts the metal object and a secondary gas blows the molten metal away. The chain saw is a Milwaukee heavy duty electric chain saw with a 16" blade, and the circular saw is a Milwaukee heavy duty electric saw with a 10.25" diameter blade. EES designed the parallel jaw gripper specifically for the telerobot and a 120 VAC electric motor drives the gripper. The plastic cutter is an electric motor that turns a flange at high speed. Two whips are attached to the flange and act as a blade. TNX Maintenance modified all the tools so they would mate with the telerobot tool change system.

Test Preparation

To prepare for this test, IWT reviewed previous telerobot reports (References 1 & 2), compiled a list of frequently used telerobot tools, and determined a maintenance procedure for each tool. Table 1 summarizes the tools and associated common maintenance required, see the test plan for more details (Reference 3).

Table 1 - Common Maintenance to Telerobot Tools

Tool	Common Maintenance
Plasma Torch	Replace tip assembly
Chain Saw	Reset blade
Chain Saw	Change blade
Chain Saw	Add oil
Circular Saw	Change Blade
Gripper	Replace sheer pin
Gripper	Reset coupling
Plastic Cutting Device (PCD)	Replace blade

Before testing began, operators inspected the telerobot tools, manually performed the tool maintenance procedures, and reviewed the hand tools required to complete the maintenance tasks.

Test Procedure

Plasma Arc Torch

This test demonstrated torch repair by replacing the four torch components. Figure 2 shows the torch housing and the four major torch components. Operators used MSMs to unscrew the cover and remove the gasket. They used MSMs and a special vendor provided wrench to loosen and remove the tip. The MSMs and a screwdriver style wrench were used to remove the electrode from the torch housing. These steps were repeated in reverse order to assemble the torch.

Chain Saw

This test demonstrated three types of chain saw maintenance: resetting the chain, replacing the chain, and adding oil. The chain saw has four major components: motor, chain, chain cover, and chain guide. To reset the chain, operators used both MSMs, a screwdriver, and a socket wrench.

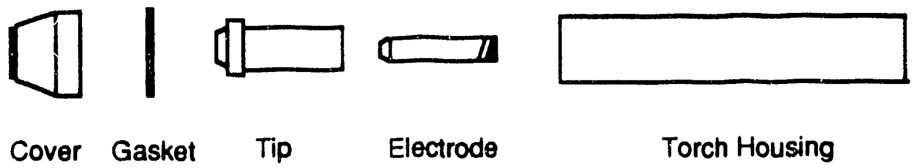

Figure 2 - Plasma Torch Assembly

First they loosened but didn't remove the chain cover, which also loosens the blade guide, with the socket wrench. Second, the chain guide was retracted by turning the guide positioning screw with the screwdriver. Third, the chain was placed in the top side of the chain guide and operators pulled the chain around the guide. This verified the chain was in the guide and on the drive sprocket. Forth, the blade was tightened by turning the guide positioning screw with the screwdriver. Fifth the chain cover was secured with the socket wrench.

For the second chain saw repair, replacing the chain, operators used the same tools as above. First, they loosened and removed the chain cover with the socket wrench and removed the old chain with the MSMs. Second, the new chain was placed over the drive sprocket and the chain cover was replaced. A handle was added to the chain cover so the MSMs could lift and hold it. At this point the blade and saw are in the starting position of the blade resetting task, so operators followed the same five steps mentioned above.

For the third chain saw repair, adding oil to the saw, operators used the MSMs and a bottle small enough for the MSMs to hold, approximately 2" diameter by 4" high. They rotated the saw on its side, removed the oil reservoir cap, poured oil into the reservoir, and replaced the cap.

Circular Saw

This test demonstrated circular saw repair by replacing the saw blade. The circular saw has three main components, the motor, blade, and blade retaining bolt. First, operators placed a screwdriver between the blade and motor housing to prevent the blade from turning. Second, they used the socket wrench to loosen and remove the blade retaining bolt. Using the socket wrench requires two MSMs, one to hold the wrench on the bolt and the other to move the wrench handle. Third, the screwdriver, lock washer, and saw blade were removed. Forth, the blade was replaced and the screwdriver was inserted between the blade and motor housing. Fifth, the lock washer was replaced and the blade retaining bolt was tightened with the socket wrench.

Gripper

Table 1 lists two types of gripper repair, replacing the sheer pin and resetting the coupling. Operators could not complete these tasks because both require turning screws that the MSMs couldn't reach or the operators couldn't see. Table 1 also lists replacing the blade on the plastic cutter, and operators could not complete this task for the same reasons.

RESULTS

Table 2 summarizes the test results. The first column lists the task, the second column, the number of MSM arms used, the third column, the number of operators, and the forth column, the time. Note: the first task, replace the torch tip, took 2 operators and 2 MSMs 34:45 (minutes:seconds) to complete the first time. By improving technique, they reduced the time to 13:15 and they realized the task could be completed with 1 MSM and 1 operator. Table 2 shows the 1 operator runs in the second row. The last three tasks on Table 2 could not be completed because they require turning small screws that the MSM grippers couldn't reach or the operators couldn't see.

Table 2 - Telerobot Tool Maintenance Results

Task	Number of MSM Arms	Number of Operators	Times(minutes:seconds)
Replace torch tip	2	2	34:45, 13:50, 13:15
Replace torch tip	1	1	12:15, 10:34
Reset Chain Saw Blade	2	2	10:15, 8:16, 8:55
Replace Chain Saw Blade	2	2	37:41, 24:08, 14:42
Add Oil to Chain Saw	1	1	2:13, 1:24, 2:00, 2:44, 2:00, 1:43
Replace Circular Saw Blade	2	2	24:08, 22:25, 8:17, 7:00, 5:37, 4:47
Replace Gripper Shear Pin	NA	NA	NA
Reset Gripper Coupling	NA	NA	NA
Replace PCD Blade	NA	NA	NA

RECOMMENDATIONS

Based on the results and experiences learned from this test, the follow four recommendations can be made:

- The telerobot gripper and plastic cutting device should be modified to allow easy remote maintenance. All future telerobot tools should be designed this way.
- Incorporate the maintenance times found in this study in future throughput studies.
- Modify an electric screwdriver for MSM use. An MSM can only turn a screw about 180 degrees at a time, so a power screwdriver will save considerable time.
- Modify an electric wrench for MSM use. Turning bolts requires 2 MSMs when using conventional socket/ratchet wrenches, so a power wrench will save considerable time.

CONCLUSIONS

Based on the results and experiences learned from this test, the following conclusions can be made:

- MSMs can complete remote maintenance on most telerobot tools.

- Remote tool maintenance can be completed in a reasonable amount of time (less than 15 minutes per task)
- When evaluating specially designed or commercial equipment for use in a remote facility, the following items should be considered:
  - Large bolts or screws
  - Easy to reach and view bolts or screws
  - Self capturing bolts or screws with self starting heads
  - A small number of bolts or screws

QUALITY ASSURANCE

Research Notebook WSRC-NB-90-395, maintained by E. M. Kriikku, contains all test data in chronological order. Data includes detailed descriptions of maintenance tasks, equipment used, general observations, operator comments, and operator performance.

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