<?php
if(!empty($_POST['Submit'])){

    $gMaterials = "materials`.`applicability``;
    $grade[] = "materials`.`applicability``;

    if(!empty($_POST['cost'])){ 
        $cost = $_POST['cost'];
        foreach($cost as $key => $value){
            $grade[] = "cost`.`" . $value . "``;
            $costGrade[] = "cost`.`" . $value . "``;
        }
    }
}

if(!empty($shape)) {
    $shapeGrade = "\shape`\$shape``;
    $grade[] = "\shape`\$shape``;
    $where[] = "\shape`\$shape` != 0``;
}

if(!empty($tolerance)){

}
$where[] = "process`.`tolerance` <= $tolerance and `process`. `tolerance` > 0";
$grade[] = '35/`process`. `tolerance`';
$processGrade[] = '35/ `process`. `tolerance`';
}
if(!empty($sfinish)){
    $where[] = "process`. `surface` <= $sfinish and `process`. `surface` > 0";
    $grade[] = '0.5/`process`. `surface`';
    $processGrade[] = '0.5/ `process`. `surface`';
}
if(!empty($sdamage)){
    $where[] = "process`. `damage` <= $sdamage and `process`. `damage` > 0";
    $grade[] = '10/`process`. `damage`';
    $processGrade[] = '10/ `process`. `damage`';
}
if(!empty($corner_radi)){
    $where[] = "process`. `corner_radi` <= $corner_radi and `process`. `corner_radi` > 0";
    $grade[] = '0.05/`process`. `corner_radi`';
    $processGrade[] = '0.05/ `process`. `corner_radi`';
}
if(!empty($taper)){
    $where[] = "process`. `taper` <= $taper and `process`. `taper` > 0";
    $grade[] = '0.005/`process`. `taper`';
    $processGrade[] = '0.005/ `process`. `taper`';
}
if(!empty($wcut)){

}
$where[] = "`process`.`wcut` <= $wcut and `process`.`wcut` > 0";
$grade[] = '0.025/`process`.`wcut`';
$processGrade[] = '0.025/`process`.`wcut`';
}
if(!empty($overcut)){
    $where[] = "`process`.`overcut` <= $overcut and
`process`.`overcut` > 0";
    $grade[] = '0.50/`process`.`overcut`';
    $processGrade[] = '0.50/`process`.`overcut`';
}
if(!empty($dia_ratio)){
    $where[] = "`process`.`dia_ratio` <= $dia_ratio and
`process`.`dia_ratio` > 0";
    $grade[] = '25/`process`.`dia_ratio`';
    $processGrade[] = '25/`process`.`dia_ratio`';
}
$tgrade = implode('+',$grade);

if(!empty($shapeGrade)) {
    $all_shapeGrade = "", $shapeGrade as sGrade";
}
if(!empty($processGrade)) {
    $all_processGrade = ',' ( . implode(' + ',',$processGrade) . ' ) as pGrade';
}
if(!empty($costGrade)) {
    $all_costGrade = ' ( . implode(' + ',',$costGrade) . ' ) as cGrade';
}
if(!empty($where)) $all_where = ' AND ' . implode(' AND ', $where);

$q2 = "SELECT * $all_processGrade $all_costGrade $all_shapeGrade
FROM `materials`, `cost`, `process`, `shape`
WHERE `materials`.`material` = '$material'
    AND `applicability` != '0'
    AND `materials`.`process` = `shape`.`process`
    AND `materials`.`process` = `cost`.`process`
    AND `materials`.`process` = `process`.`process`
    $all_where
ORDER BY ($tgrade) DESC ";

$r2 = mysql_query($q2);

?>
APPENDIX 2

ADDITIONAL CASE STUDIES OF WEKBS

CASE STUDY 11
Problem Statement

A machining sample specimen for WEDM as shown in Figure A 2.1 is used to demonstrate the ‘profile with and without V corner control’ is made of D2 Steel with 28 mm thickness and a bass wire of diameter 0.2 mm is used to cut the given profile in three passes. The time taken to complete this profile cutting is 2 hrs 12 min each.

Limiting Requirements

Limiting requirements for this example are as follows:

- Material : D2 Steel
- Shape Application : Profile cutting (shallow)
- Min.Surface finish : 0.3 µm Ra
- Min.Tolerance : ± 30 µm
- Min.Taper : 0 (i.e., not given)
- Depth of Cut : 28 mm
- Min.Corner radii of the part : 0 (i.e., not given).

Observation

From the sample result of the program shown in Figure 6.4, it is observed that WEDM, ECH, ECG, ECM, USM, and EDM are found to be the
most suitable NTMPs for the given part in order of preference in the final selection list (Mitsubishi 2008).

Figure A2.1 Specimen of Profile cutting for Case study 11

CASE STUDY 12

Problem Statement

An electronic part stamping punch made of D2 Steel with thickness 101 mm, cut by WEDM is as shown in Figure A 2.2 is used for several years to check the vertical accuracy of profile cutting of a WEDM machine. A brass wire of 0.2 mm is used to cut the specimen in a single pass and the time taken to complete the through cutting is 2 hrs 41 min. The vertical accuracy obtained is 0.004 mm.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Requirement Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>D2 Steel</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Profile cutting (deep)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>0.5 µm Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>± 4 µm</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0 (i.e., not given)</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>101 mm.</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given)</td>
</tr>
</tbody>
</table>
Observation

It is observed from the results of WEKBS that only WEDM is found to be the most suitable NTMP for this application (Mitsubishi 2008).

Figure A2.2 An electronic part stamping Punch for Case study 12

CASE STUDY 13

Problem Statement

A test Specimen used to test Staircase machining by WEDM is shown in Figure A2.3. The specimen cut is performed on High Carbon High Chromium Steel (HCHCR). A brass wire of 0.2 mm is used to cut steps of 10mm thick specimen. The Surface Finish obtained is 5.6 μm. The time taken is 1 hr 33 min. The dimensional accuracy achieved for one pass staircase machining is shown in Table A2.1.
Limiting Requirements

Limiting requirements for this example are as follows:

Material : Tool Steel
Shape Application : Through cutting (shallow)
Min. Surface finish : 5.6 μm Ra
Min. Tolerance : ± 30 μm
Min. Taper : 0 (i.e., not given)
Depth of Cut : 10 mm
Min. Corner radii of the part : 0 (i.e., not given).

Observation

It is observed from the results of WEKBS that the most suitable NTMPs for this example are WEDM, ECH, ECG, USM, CHM, EDM, and USM in order of preference (Mitsubishi 2008).

Table A2.1 Dimensional accuracy for one pass staircase machining

<table>
<thead>
<tr>
<th>Step Thickness(mm)</th>
<th>Dimension Required(mm)</th>
<th>Achieved(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
<td>9.9843</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
<td>9.9798</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
<td>9.9891</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
<td>9.9854</td>
</tr>
<tr>
<td>50</td>
<td>20</td>
<td>19.9927</td>
</tr>
</tbody>
</table>
CASE STUDY 14

Problem Statement

The small scale industry currently employs WEDM to produce a forming punch made of OHNS hardened to 60-61 HRc. The part Ø65 × 110 mm has six teeth. The tolerance and surface finish achieved are ± 0.03mm and 0.3 Ra respectively.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>OHNS</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Through cutting (deep)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>0.3 μm Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>± 30 μm</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0 (i.e., not given)</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>65 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given)</td>
</tr>
</tbody>
</table>
Observation

From the results of the WEKBS, it is observed that WEDM, ECH, ECG, USM and EDM are the most suitable NTMPs for the given application in order of preference. (Lucas 2008).

CASE STUDY 15
Problem Statement

A Specimen used for testing the pitch accuracy obtained in a WEDM machine is shown in Figure A2.4. The specimen is made of High Carbon High Chromium Steel (HCHCR) and its thickness is 30 mm. A brass wire of 0.2 mm with three passes is used to cut the specimen in 29 min. The surface finish obtained is 4.2 µm.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Steel</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Through cutting (shallow)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>4.6 µm Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>± 1 µm</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0 (i.e., not given)</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>30 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given)</td>
</tr>
</tbody>
</table>

Observation

It is observed from the results of WEKBS that only WEDM is found to be the most suitable NTMP for this application (Mitsubishi 2008).
CASE STUDY 16

Problem Statement

A specimen used for testing EDM die sinking machine made of HCHCR Steel with 40-42 HRc is as shown in Figure A2.5. The Two Copper electrodes are used to finish the mirror finish cavity. The Spark gab for roughing and finishing are each 0.2 mm/side. Surface Finish and the machining depth obtained are 0.2 μm Rmax and 4.5 mm respectively. The roughing, finishing and polishing time are 22 min, 1hr 04 min, and 3 hrs 12 min respectively.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>HCHCR Steel</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Pocketing (shallow)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>0.2 μm Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>± 30 μm</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0.001 mm/mm</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>4.5 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given).</td>
</tr>
</tbody>
</table>
Observation

It is observed from the results of WEKBS that the most suitable NTMPs for this example are ECH, ECG, EDM, and USM (Mitsubishi 2008).

Figure A2.5 Mirror finish cavity test specimen for Case study 15

CASE STUDY 17

Problem Statement

A Tablet punch made of HCHCR Steel is machined by EDM is as shown in Figure A2.6. The surface finish and machining depth obtained are 4 μm Rmax and 5 mm respectively. The discharge area is 7 sq. mm. The roughing and finishing time taken are 21 min and 25 min respectively.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>HCHCR Steel</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Through cutting (shallow)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>4 µm Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>± 30 µm</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0 (i.e., not given)</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>5 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given)</td>
</tr>
</tbody>
</table>
Observation

It is observed from the results of WEKBS that the most suitable NTMPs for this example are WEDM, ECH, ECG, USM, CHM, and LBM (Mitsubishi 2008).

Figure A2.6 Spark eroded Tablet Punch for Case study 17

CASE STUDY 18

Problem Statement

A Pen die block cavity is machined by EDM several years. The Work material is HCHCR Steel and the electrode material is copper. Work material hardness is 40-42 HRc . Depth of cut is 10mm . In one trial, it is observed that the roughing, finishing and polishing time taken are 48 min, 24 min, and 3 hrs 52 min respectively.

Limiting Requirements

Limiting requirements for this example are as follows:

Material : HCHCR Steel  
Shape Application : Pocketing (shallow)  
Min. Surface finish : 0.3 µm Ra  
Min. Tolerance : ± 30 µm  
Min. Taper : 0 (i.e., not given)  
Depth of Cut : 10 mm  
Min. Corner radii of the part : 0 (i.e., not given).
Observation

It is observed from the results of WEKBS that the most suitable NTMPs for this example are ECH, ECG, EDM, and USM (Mitsubishi 2008).

Figure A2.7 Pen Die Block for Case study 18

CASE STUDY 19

Problem Statement

A Bottom stop complex made of HCHCR Steel machined by EDM is as shown in Figure A2.8. In order to machine the cavity, the orbiting method used is spherical. The surface finish and machining depth obtained are 6 \( \mu m \) Rmax and 14 mm respectively. The total machining time for forming the cavities is 4 hrs 41 min.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>HCHCR Steel</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Pocketing (shallow)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>6 ( \mu m ) Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>( \pm 20 \mu m )</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0.001 mm/mm</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>14 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given).</td>
</tr>
</tbody>
</table>
Observation

It is observed from the results of WEKBS that the most suitable NTMPs for this example are ECH, and USM (Mitsubishi 2008).

![Figure A2.8 Bottom Stop Complex made of Steel for Case study 19](image)

CASE STUDY 20

Problem Statement

A test specimen made of Mild steel cut by LBM is as shown in Figure 2.10. The thickness of the specimen is 4.5 mm. The power spent for machining is 2 kW and the cycle time is 26 seconds.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Mild Steel</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Through cutting (shallow)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>2 ( \mu \text{m} ) Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>( \pm 30 \mu \text{m} )</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0 (i.e., not given)</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>4.5 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given).</td>
</tr>
</tbody>
</table>
Observation

It is observed from the results of WEKBS that the most suitable NTMPs for this example are WEDM, ECH, ECG, USM, CHM, EDM and LBM (Mitsubishi 2008).

Figure A2.9 Test specimen cut by LBM for Case study 20

CASE STUDY 21

Problem Statement

The Automotive ancillary unit currently employs EDM to produce claw-forming die made of OHNS. The part of Ø220 × 100 mm has six complex blind cavities. The depth of cut is 60 mm. In one application the quality control check on the tolerance and surface finish achieved was within ± 0.03 mm and 0.2 µm Ra, respectively.

Limiting Requirements

Limiting requirements for this example are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Requirement Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>OHNS</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Pocketing (deep)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>4.2 µm Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>± 30 µm</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0 (i.e., not given)</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>60 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given)</td>
</tr>
</tbody>
</table>
Observation

From the sample result of the program it is observed that ECH, ECG, ECM, USM, and CHM are the most suitable for the given part (Lucas 2008).

CASE STUDY 22

Problem Statement

The small scale industry currently employs EDM to produce a commutator inner profile die block made of D2 Steel. The part Ø45 × 140 mm has 23 complex blind cavities. The depth of pocket is 45 mm. The tolerance and surface finish achieved are within ±0.03mm and 0.5 μm Ra respectively. The corner radii and minimum taper of the part are 0.4mm and 0.001 mm/mm respectively.

Limiting Requirements

Limiting requirements for this example are as follows:

Material : D2 Steel
Shape Application : Pocketing (shallow)
Min.Surface finish : 0.5 μm Ra
Min.Tolerance : ±30 μm
Min.Taper : 0 (i.e., not given)
Depth of Cut : 23 mm
Min.Corner radii of the part : 0 (i.e., not given).

Observation

It is observed from the developed knowledge base system that ECH, ECG, EDM, USM, and CHM are found to be the most suitable NTMPs for the given part (Concorde 2008).
CASE STUDY 23

Problem Statement

The Automotive ancillary unit currently employs EDM to produce a punch made of OHNS. The part of Ø220 × 100 mm has six teeth. In one application the quality control check on the tolerance and surface finish achieved was within ± 0.015 mm and 0.2 µm Ra, respectively.

Limiting Requirements

Limiting requirements for this example as shown in Figure 6.1 are as follows:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>OHNS</td>
</tr>
<tr>
<td>Shape Application</td>
<td>Profile cutting (shallow)</td>
</tr>
<tr>
<td>Min. Surface finish</td>
<td>4.2 µm Ra</td>
</tr>
<tr>
<td>Min. Tolerance</td>
<td>± 15 µm</td>
</tr>
<tr>
<td>Min. Taper</td>
<td>0 (i.e., not given)</td>
</tr>
<tr>
<td>Depth of Cut</td>
<td>100 mm</td>
</tr>
<tr>
<td>Min. Corner radii of the part</td>
<td>0 (i.e., not given).</td>
</tr>
</tbody>
</table>

Observation

From the sample result of the program it is observed that WEDM, ECH, ECG, and LBM are the most suitable for the given part in order of preference.
CASE STUDY 24

Problem Statement

A Die Block cavity made of Super Alloy is machined by WEDM and cavity is finished by EDM. The surface finish and machining depth obtained are 3 µm Rmax and 14 mm respectively. The time taken for pre-machining and cavity forming are 17 min and 12 min respectively.

Limiting Requirements

Limiting requirements for this example as shown in Figure 6.1 are as follows:

- Material: Super Alloy
- Shape Application: Pocketing (shallow)
- Min. Surface finish: 3 µm Ra
- Min. Tolerance: ± 30 µm
- Min. Taper: 0 (i.e., not given)
- Depth of Cut: 14 mm
- Min. Corner radii of the part: 0 (i.e., not given).

Observation

It is observed from the results of WEKBS that the most suitable NTMPs for this example are ECH, ECG, EDM, USM, and CHM (Mitsubishi 2008).
CASE STUDY 25

Problem Statement

The drilling of turbine engine combustor domes made of super-alloy with HRC35 has been performed for several years using EBM. The part has a wall thickness of 1.1 mm and is perforated with 3748 holes that are 0.9 mm in diameter with ± 0.05 mm tolerance. Each part is drilled for 60 min with a drilling rate of approximately one hole every second.

Limiting Requirements

Limiting requirements for this example are as follows:

Material : Super alloy
Min.Surface finish : 0 (i.e., not given)
Min.Tolerance : ± 50 µm
Min.Taper : 0 (i.e., not given)
Depth of Cut : 1.1 mm
L/D ratio : 1.2 (=1.1/0.9)

Observation

WEDM, ECH, ECG, ECM, EDM, WJM, USM, AJM, LBM, and EBM are found to be the most suitable NTMPs for the given part in order of preference.