



Manufacturing Process Optimization Using Open Data and Different Analysis Methods

This study examines the effect of various Control Variables (CV) on an Evaluation Variable (EV) for optimizing the material removal process (machining)

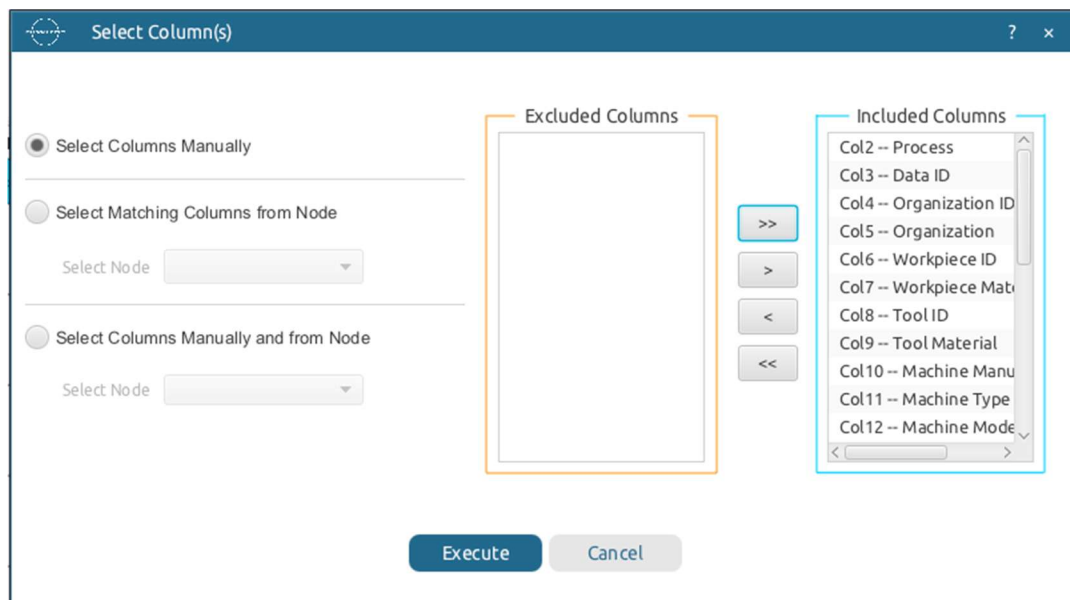
The variables examined are T_w = Tool Wear [mm], as a dependent variable and v_c = Cutting Speed [m/min], f = Feed [mm/rev], T_m = Machining Time [min] as factors

Isalos version used: 2.1.2

Scientific article: <https://www.mdpi.com/2504-4494/9/4/106>

Step 1: Partition data according to Tool Material

Import dataset and rename the tab to “Data”. Go to Data Transformation → Data Manipulation → Select Column(s), transfer all columns to “Included Columns” and click execute



Create a new tab named “TM1”, import the spreadsheet from “Data” then select only the entries with Tool Material = “Cermet: TiN-TaN” by going to Data Transformation → Data Manipulation → Filter Data, check the “Apply Criteria Filters” box and under “Equality/Inequality Criterion” select “Col9 – Tool Material = Cermet: TiN-TaN”, then click “Add Criterion” and “Execute”

Filter Data

Filter: ☒ Rows ☐ Columns

Mode:

- ☒ Include
- ☐ Exclude

Base Selection Meth...

- ☒ Select All
- ☐ Select Ranges

Additional Options:

- ☒ Apply Criteria Filters
- ☐ Exclude Rows/Cols with Missing Values
- ☐ Exclude Duplicate Rows/Cols

From: To: Add Range

Define Selection Criteria:

Equality/Inequality Criterion

Cardinality Criterion

Values: ≤ Value Count: < Count

Add Criterion

Active Criteria:

Col9 -- Tool Material = Cermet: TiN-TaN

Remove

Clear All

Match: ☒ All criteria (AND) ☐ Any criteria (OR)

Excluded

Row 1

Row 2

Row 3

Row 4

Row 5

Row 6

Row 7

Row 8

Row 9

Row 10

Included

Row 22

Row 23

Row 24

Row 25

Row 26

Row 27

Row 28

Row 29

Row 30

Row 31

Execute Cancel

Create a new tab named “TM2”, import the spreadsheet from “Data” then select only the entries with Tool Material = “Ceramics: TiCN-30TiB₂-1TaN” by going to **Data Transformation** → **Data Manipulation** → **Filter Data**, check the “Apply Criteria Filters” box and under “Equality/Inequality Criterion” select “Col9 – Tool Material = Ceramics: TiCN-30TiB₂-1TaN”, then click “Add Criterion” and “Execute”

Filter Data

Filter: ☒ Rows ☐ Columns

Mode:

- ☒ Include
- ☐ Exclude

Base Selection Meth...

- ☒ Select All
- ☐ Select Ranges

Additional Options:

- ☒ Apply Criteria Filters
- ☐ Exclude Rows/Cols with Missing Values
- ☐ Exclude Duplicate Rows/Cols

From: To: Add Range

Define Selection Criteria:

Equality/Inequality Criterion

Cardinality Criterion

Values: ≤ Value Count: < Count

Add Criterion

Active Criteria:

Col9 -- Tool Material = Ceramics: TiCN-30TiB₂-1TaN

Remove

Clear All

Match: ☒ All criteria (AND) ☐ Any criteria (OR)

Excluded

Row 22

Row 23

Row 24

Row 25

Row 26

Row 27

Row 28

Row 29

Row 30

Row 31

Included

Row 1

Row 2

Row 3

Row 4

Row 5

Row 6

Row 7

Row 8

Row 9

Row 10

Execute Cancel

Step 2: ANOVA with Cutting Speed (v_c)

Create a new tab named “Cutting Speed (TM1)” and import the spreadsheet from the “TM1” tab. To perform the analysis, go to Statistics → Analysis of (Co)Variance → One Way ANOVA and enter “Cutting Speed” as Factor, “Tool Wear” as Response Variable and then, click Execute

	Col1	Col2 (S)	Col3 (I)	Col4 (I)	Col5 (S)	Col6 (I)	Col7 (S)	Col8 (I)	
User Header	User Row ID	Process	Data ID	Organization ID	Organization	Workpiece ID	Workpiece Material	Tool ID	
1	646	Turning	647	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti
2	647	Turning	648	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti
3	648	Turning	649	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti
4	649	Turning	650	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti
5	650	Turning	651	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti
6	651	Turning	652	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti
7	652	Turning	653	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti
8	653	Turning	654	8	H	14	Carbon steel for machine structure (S45C)	16	C Ti

One-Way ANOVA

Factor

Col15 -- Cutting Spee...

Response Variable

Col27 -- Tool Wear [...]

Execute

Cancel

The results are shown in the right spreadsheet:

	Col1	Col2 (D)	Col3 (D)	Col4 (D)	Col5 (D)	Col6 (D)	Col7 (D)	Col8 (D)	Col9 (D)	Col10 (D)
User Header	User Row ID	SSB (Between Groups):	SSW (Within Groups):	SST (Total):	dfB (Between):	dfW (Within):	MSB:	MSW:	F-statistic:	p-value:
1		0.4507986	0.8744524	1.3252510	2.0	65.0	0.2253993	0.0134531	16.7544312	0.0000014

Create a new tab named “Cutting Speed (TM2)” and do the same, but import the spreadsheet from the “TM2” tab. Results are shown in the right spreadsheet:

	Col1	Col2 (D)	Col3 (D)	Col4 (D)	Col5 (D)	Col6 (D)	Col7 (D)	Col8 (D)	Col9 (D)	Col10 (D)
User Header	User Row ID	SSB (Between Groups):	SSW (Within Groups):	SST (Total):	dfB (Between):	dfW (Within):	MSB:	MSW:	F-statistic:	p-value:
1		0.0584366	0.1930933	0.2515299	2.0	39.0	0.0292183	0.0049511	5.9013656	0.0057672

Step 3: ANOVA with Feed (f)

Create a new tab named “Feed (TM1)” and import the spreadsheet from the “TM1” tab. To perform the analysis, go to Statistics → Analysis of (Co)Variance → One Way ANOVA and enter “Feed” as Factor, “Tool Wear” as Response Variable and then, click Execute

One-Way ANOVA

Factor: Col16 -- Feed [mm/rev]

Response Variable: Col27 -- Tool Wear [...]

Execute Cancel

The results are shown in right spreadsheet:

	Col1	Col2 (D)	Col3 (D)	Col4 (D)	Col5 (D)	Col6 (D)	Col7 (D)	Col8 (D)	Col9 (D)	Col10 (D)
User Header	User Row ID	SSB (Between Groups):	SSW (Within Groups):	SST (Total):	dfB (Between):	dfW (Within):	MSB:	MSW:	F-statistic:	p-value:
1		0.1779618	1.1472892	1.3252510	1.0	66.0	0.1779618	0.0173832	10.2375935	0.0021158

Create a new tab named “Feed (TM2)” and do the same, but import the spreadsheet from the “TM2” tab. Results are shown in the right spreadsheet:

	Col1	Col2 (D)	Col3 (D)	Col4 (D)	Col5 (D)	Col6 (D)	Col7 (D)	Col8 (D)	Col9 (D)	Col10 (D)
User Header	User Row ID	SSB (Between Groups):	SSW (Within Groups):	SST (Total):	dfB (Between):	dfW (Within):	MSB:	MSW:	F-statistic:	p-value:
1		0.0071501	0.2443798	0.2515299	1.0	40.0	0.0071501	0.0061095	1.1703250	0.2858134

Step 4: ANOVA with Machining Time (T_m)

Create a new tab named “Machine Time (TM1)” and import the spreadsheet from the “TM1” tab. To perform the analysis, go to Statistics → Analysis of (Co)Variance → One Way ANOVA and enter “Time” as Factor, “Tool Wear” as Response Variable and then, click Execute

One-Way ANOVA

Factor: Col26 -- Time [min]

Response Variable: Col27 -- Tool Wear [...]

Execute Cancel

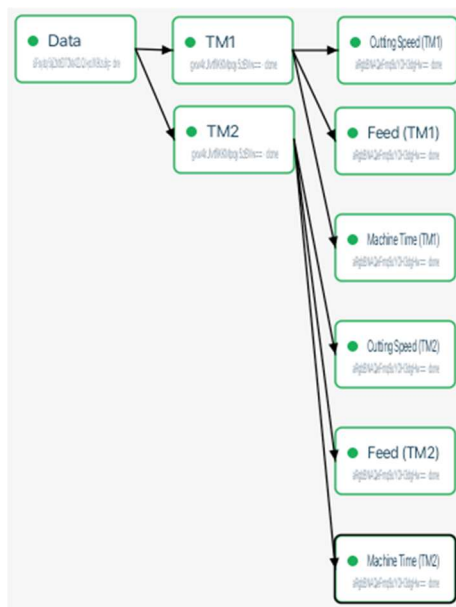
The results are shown in the right spreadsheet:

	Col1	Col2 (D)	Col3 (D)	Col4 (D)	Col5 (D)	Col6 (D)	Col7 (D)	Col8 (D)	Col9 (D)	Col10 (D)
User Header	User Row ID	SSB (Between Groups):	SSW (Within Groups):	SST (Total):	dfB (Between):	dfW (Within):	MSB:	MSW:	F-statistic:	p-value:
1		0.2828036	1.0424474	1.3252510	6.0	61.0	0.0471339	0.0170893	2.7580961	0.0194387

Create a new tab named “Feed (TM2)” and do the same, but import the spreadsheet from the “TM2” tab. Results are shown in the right spreadsheet:

	Col1	Col2 (D)	Col3 (D)	Col4 (D)	Col5 (D)	Col6 (D)	Col7 (D)	Col8 (D)	Col9 (D)	Col10 (D)
User Header	User Row ID	SSB (Between Groups):	SSW (Within Groups):	SST (Total):	dfB (Between):	dfW (Within):	MSB:	MSW:	F-statistic:	p-value:
1		0.1539992	0.0975307	0.2515299	6.0	35.0	0.0256665	0.0027866	9.2107326	0.0000046

Final Isalos Workflow:



References:

Tahiduzzaman, M., Ghosh, A. K., & Ura, S. (2025). Manufacturing Process Optimization Using Open Data and Different Analysis Methods. *Journal of Manufacturing and Materials Processing*, 9(4), 106. <https://doi.org/10.3390/jmmp9040106>