Signal to Noise Ratio

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Outline

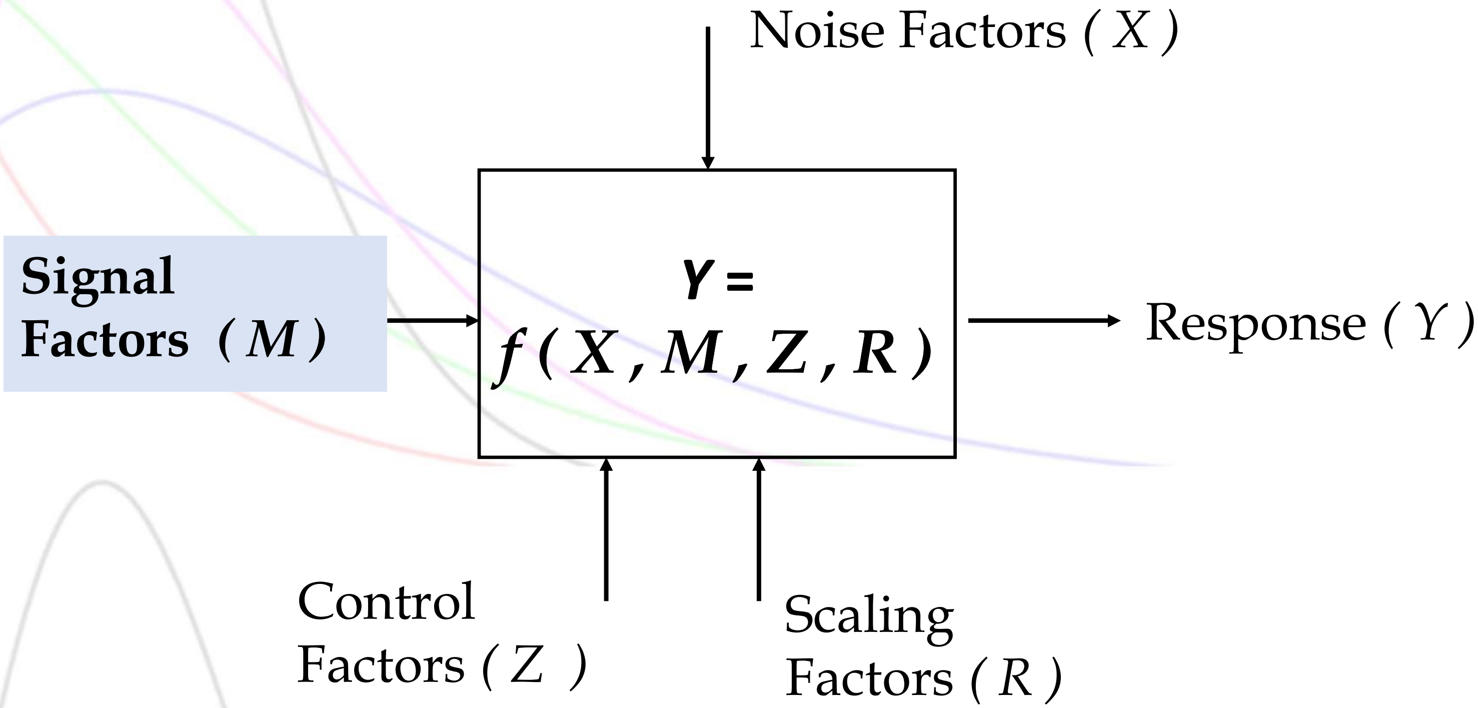
- Signal to noise ratios for static problems
- Application of signal to noise ratio – smaller the better
- Fraction defective analysis

SN ratio for static problems

DOE in Taguchi Method can be classified

1. Static functions
   Fixed target (specific value)
2. Dynamic functions
   Variable target

Factors affecting a response



Signal factor

- Signal factor in TV sony system (static system) → constant → evaluate control and noise factor
- Signal factor in car breaking system (dynamic system) → The harder driver presses on the brake pedal

Importance of the SN ratio

- The objective of robust design → **minimize** the sensitivity of a quality characteristic to noise factors → based on mean square deviation

$$MSD = \sigma^2 + \left(\bar{y} - m\right)^2$$

Importance of the SN ratio

- $y = f(X, M, Z, R)$
- In reality → function consisting

  → predictable and unpredictable part

$$y = g(M, Z, R) + e(X, M, Z, R)$$

- The objective of robust design →**maximize** predictable and **minimize** unpredictable part

Importance of the SN ratio

- From experiment → variance of the predictable part (V_g) and variance of the unpredictable part (V_e)
- Taguchi quality evaluation

$$\eta = \frac{\text{signal}}{\text{noise}} = \frac{\text{variance of the predictable part}}{\text{variance of the unpredictable part}} = \frac{V_g}{V_e}$$

Importance of the SN ratio

$$\eta = 10\log_{10}\left[\frac{\text{variance of the predictable part}}{\text{variance of the unpredictable part}}\right]$$

$$= 10\log_{10}\left[\frac{V_g}{V_e}\right]$$

$$\eta(Z,R) = 10\log_{10}\left[\frac{V_g(Z,R)}{V_e(Z,R)}\right]$$

$$\eta(Z) = \max \eta(Z, R\ \text{constant})$$

When signal factor is constant

$$\eta = -10\log_{10}[MSD]$$

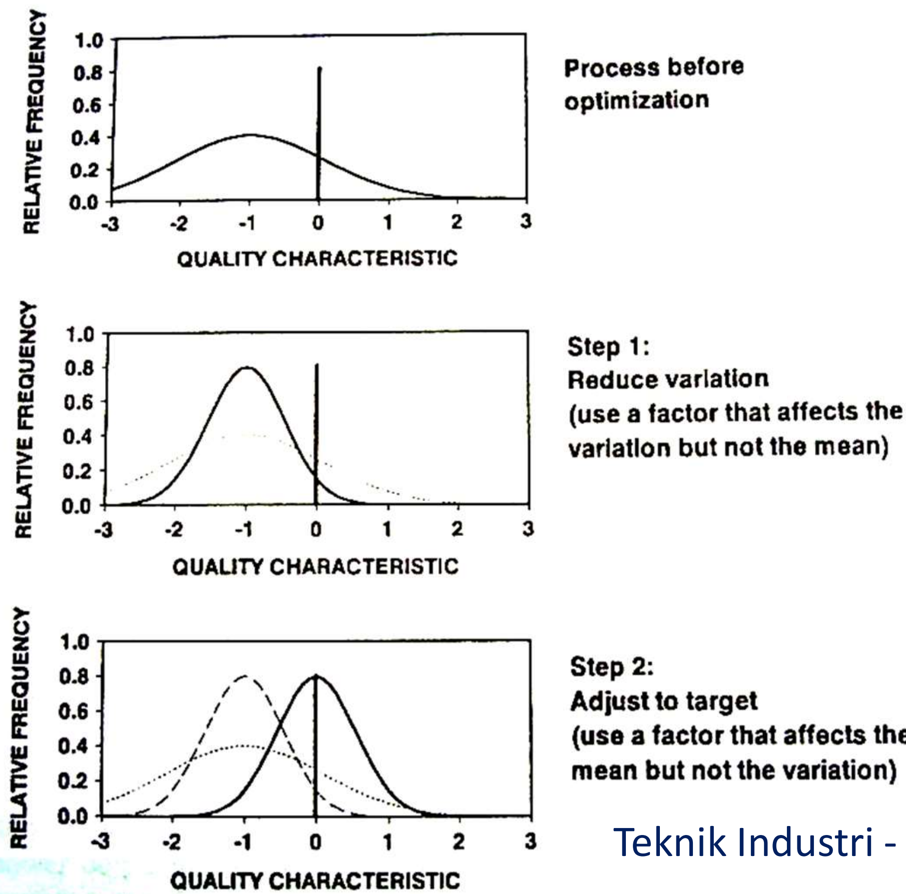
SN-ratio

- Nominal the best
- Smaller the better
- Larger the better
- Fraction defective

SN-ratio - Nominal the best

$$\eta = 10\log_{10}\left[\frac{\mu^2}{\sigma^2}\right]$$

Two step optimization process



SN-ratio – Smaler The Better

SN $= -10 \log_{10}\left(\frac{1}{n}\sum_{i=1}^{n} y_i^2\right).$

SN-ratio – Larger The Better

$$\eta = -10 \log \left(\frac{1}{n} \sum_{i=1}^{n} \frac{1}{Y_i^2} \right)$$

SN-ratio fraction defective

$$\eta = -10 \log\left(\frac{1}{p-1}\right) \quad \text{or} \quad \eta = 10 \log\left(\frac{p}{1-p}\right)$$

Example : Smaller the better case study

Optimasi *roundness* (kebulatan) pada *part Outer Ring.*

Example : Smaller the better case study

Setting Level Faktor

Setting Faktor & Level				
Kode	Nama Faktor	Level 1	Level 2	Level 3
A	Speed Ratio	36	30	24
B	Sizematic Fine Position	20 µm/s	18 µm/s	15 µm/s
C	Spark Out	0,5 s	0,3 s	0,2 s

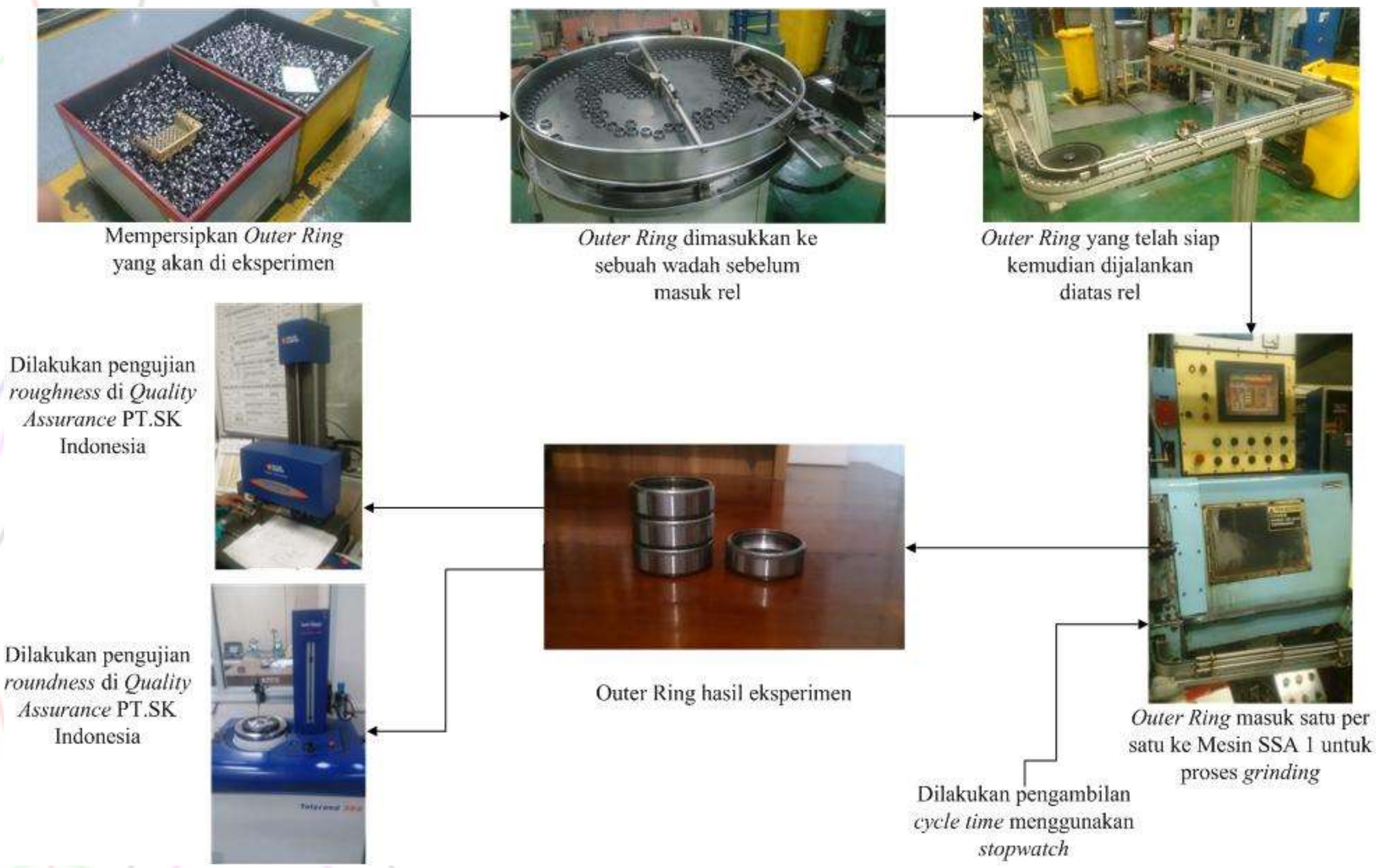
Example : Smaller the better case study

Orthogonal Array

Table 2. L_9 (3^4) Standard orthogonal array.

Experiment no.	Factor A	Factor B	Factor C	Factor D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

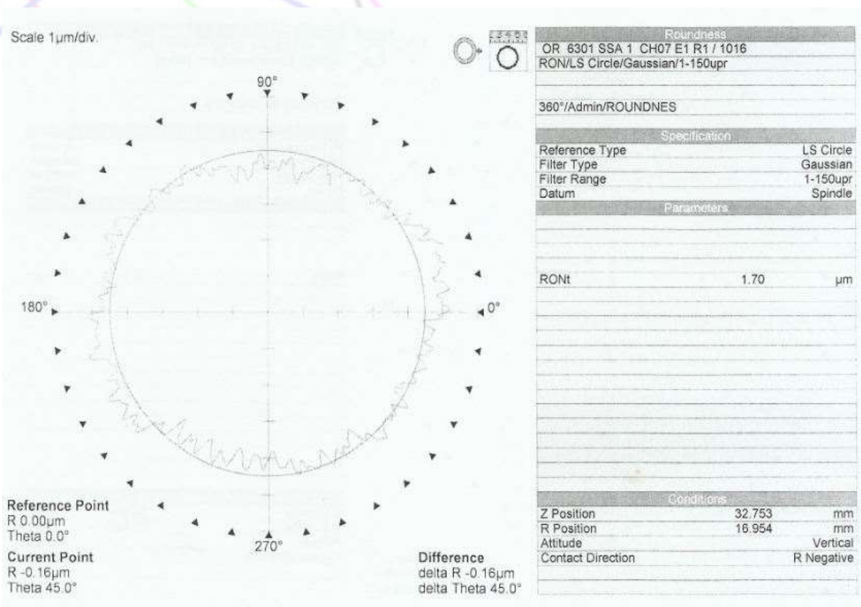
Example : Smaller the better case study



Pelaksanaan Eksperimen

Example : Smaller the better case study

Pengujian menggunakan TALYROND 365.



Example : Smaller the better case study

Hasil Pengujian

Hasil Pengujian Roundness						
No	Faktor dan Level			Roundness (µm)		
	Speed Ratio	Sizematic Fine Position	Spark Out	R-1	R-2	R-3
1	36	20 µm/s	0,5 s	1,7	1,65	2,11
2	36	18 µm/s	0,3 s	1,21	2,18	2,13
3	36	15 µm/s	0,2 s	1,66	2,48	1,56
4	30	20 µm/s	0,3 s	1,74	1,91	1,51
5	30	18 µm/s	0,2 s	1,6	2,09	1,93
6	30	15 µm/s	0,5 s	1,78	1,55	1,59
7	24	20 µm/s	0,2 s	4,28	2,9	2,7
8	24	18 µm/s	0,5 s	1,55	1,76	2,31
9	24	15 µm/s	0,3 s	3,8	1,84	1,53

Example : Smaller the better case study

Analisis berdasarkan nilai rata rata

Hasil Pengujian Roundness							
No	Faktor dan Level			Roundness (µm)			Rata-rata
	Speed Ratio	Sizematic Fine Position	Spark Out	R-1	R-2	R-3	
1	36	20 µm/s	0,5 s	1,7	1,65	2,11	1,820
2	36	18 µm/s	0,3 s	1,21	2,18	2,13	1,840
3	36	15 µm/s	0,2 s	1,66	2,48	1,56	1,900
4	30	20 µm/s	0,3 s	1,74	1,91	1,51	1,720
5	30	18 µm/s	0,2 s	1,6	2,09	1,93	1,873
6	30	15 µm/s	0,5 s	1,78	1,55	1,59	1,640
7	24	20 µm/s	0,2 s	4,28	2,9	2,7	3,293
8	24	18 µm/s	0,5 s	1,55	1,76	2,31	1,873
9	24	15 µm/s	0,3 s	3,8	1,84	1,53	2,39

Example : Smaller the better case study

Analisis berdasarkan nilai rata rata

Membuat tabel respon untuk nilai rata-rata

$$A1 = \frac{1{,}820 + 1{,}840 + 1{,}9}{3}$$

$$= 1{,}853$$

Tabel Respon Pengujian Roundness			
	A	B	C
Level 1	1,853	**2,278**	1,778
Level 2	1,744	1,862	1,983
Level 3	**2,519**	1,977	**2,356**
Selisih	0,774	0,416	0,578
Ranking	1	3	2

Example : Smaller the better case study

Analisis berdasarkan nilai rata rata

Faktor berpengaruh

Rank	Faktor	Level
1	A	1
2	C	1
3	B	2

Example : Smaller the better case study

Analisis berdasarkan nilai SN ratio

Contoh perhitungan *Signal to Noise Ratio* (SNR)

Karakteristik *Roundness* eksperimen ke-1 adalah:

$$SNR_{STB} = -10\log\left[\frac{1}{n}\sum_{i=1}^{n} y_i^2\right]$$

$$= -10\log\left[\frac{1}{3}\times\left(1{,}70^2+1{,}65^2+2{,}11^2\right)\right] = -5{,}257$$

Perhitungan SNR Roundness							
No	Faktor dan Level			Roundness(μm)			SNR
	Speed Ratio	Sizematic Fine Position	Spark Out	R-1	R-2	R-3	
1	36	20 μm/s	0,5 s	1,70	1,65	2,11	**-5,257**
2	36	18 μm/s	0,3 s	1,21	2,18	2,13	-5,544
3	36	15 μm/s	0,2 s	1,66	2,48	1,56	-5,775
4	30	20 μm/s	0,3 s	1,74	1,91	1,51	-4,750
5	30	18 μm/s	0,2 s	1,60	2,09	1,93	-5,504
6	30	15 μm/s	0,5 s	1,78	1,55	1,59	-4,313
7	24	20 μm/s	0,2 s	4,28	2,90	2,70	-10,546
8	24	18 μm/s	0,5 s	1,55	1,76	2,31	-5,578
9	24	15 μm/s	0,3 s	3,80	1,84	1,53	-8,275

Example : Smaller the better case study

Analisis berdasarkan nilai SN ratio

Tabel SN ratio			
	A	B	C
Level 1	-5,525	-6,851	**-5,049**
Level 2	**-4,856**	**-5,542**	-6,190
Level 3	-8,133	-6,121	-7,275
Selisih	3,277	1,309	2,226
Ranking	1	3	2

Example : Smaller the better case study

Analisis berdasarkan nilai SN ratio

Faktor berpengaruh

Rank	Faktor	Level
1	A	2
2	C	1
3	B	2

Example : Smaller the better case study

Analisis berdasarkan nilai rata rata dan SN ratio

Faktor berpengaruh

Rata – rata

Rank	Faktor	Level
1	A	1
2	C	1
3	B	2

SN ratio

Rank	Faktor	Level
1	A	2
2	C	1
3	B	2

Mana yang dipilih ?

Fraction defective analysis

- Example : wave soldering process
- Holes in a printed circuit board get blocked by solder bridging.
- It is a defect since components cannot be inserted in these bridging holes.

Factors and level

	Factor	Level 1	Level 2
A	Flux type	Existing	New
B	Flux density	Low	High
C	Solder temperature	Low	High
D	Solder wave height	Low	High
E	Preheat setting	3	6
F	Flux air-knife angle	45°	90°
G	Hot air blast	Yes	No

Results

Exp	A	B	C	D	E	F	G	None	Some	Severe	Total
1	1	1	1	1	1	1	1	15	4	1	20
2	1	1	1	2	2	2	2	5	13	2	20
3	1	2	2	1	1	2	2	8	12	0	20
4	1	2	2	2	2	1	1	2	11	7	20
5	2	1	2	1	2	1	2	17	2	1	20
6	2	1	2	2	1	2	1	4	15	1	20
7	2	2	1	1	2	2	1	7	13	0	20
8	2	2	1	2	1	1	2	3	11	6	20

Response table

		A	B	C	D	E	F	G
None	Level 1	30	41	30	47	30	37	28
	Level 2	31	20	31	14	31	24	33
Some	Level 1	40	34	41	31	42	28	43
	Level 2	41	47	40	50	39	53	38
Severe	Level 1	10	5	9	2	8	15	9
	Level 2	8	13	9	16	10	3	9
Difference None		1	21	1	33	1	13	5
Difference Some		1	13	1	19	3	25	5
Difference Severe		2	8	0	14	2	12	0
Rank		6	3	7	1	5	2	4

Fraction defective analysis

$$\bar{y} = \frac{\textit{total number in category}}{\textit{total number of observations}}$$

$$= \frac{18}{160}$$

$$= 0.1125$$

Fraction defective analysis

The process average at the predicted optimum condition $P_{Predicted}$ is:

$$P_{Predicted} = \bar{y} + (\overline{D1} - \bar{y}) + (\overline{F2} - \bar{y}) + (\overline{B1} - \bar{y})$$

$$= \overline{D1} + \overline{F2} + \overline{B1} - 2 \times \bar{y}$$

$$= \frac{2}{80} + \frac{3}{80} + \frac{5}{80} - 2 \times \frac{18}{160}$$

$$= -0.10$$

$$= -10\ \%$$

Fraction defective analysis

$$\Omega_{D1} = -10\ \log_{10}\left(\frac{1}{p} - 1\right)$$

$$= -10\ \log_{10}\left(\frac{1}{0.025} - 1\right)$$

$$= -10\ \log_{10}(40 - 1)$$

$$= -15.91\ \text{dB}$$

Fraction defective analysis

$$\Omega_{Predicted} = \bar{\Omega} + (\Omega_{D1} - \bar{\Omega}) + (\Omega_{F2} - \bar{\Omega}) + (\Omega_{B1} - \bar{\Omega})$$

$$= \Omega_{D1} + \Omega_{F2} + \Omega_{B1} - 2 \times \bar{\Omega}$$

$$= -15.91 - 14.09 - 11.76 - 2 \times (-8.97)$$

$$= -23.82 \text{ dB}$$

Fraction defective analysis

$$p = \frac{1}{1 + 10^{\frac{\Omega}{-10}}}$$

$$= \frac{1}{1 + 10^{\frac{23.82}{10}}}$$

$$= 0.0041$$

$$= 0.41\ \%$$

wave soldering process conclusion

- Significant factors → D , F and B
- Percent defective → 41 %

Berikutnya

Mengelola eksperimen