Spinning RingMachine Parameter SettingtoMinimalizetheVariation of String StretchQualitybyTaguchi Method

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Abstract*—One of the important factors that influence the firm sustainability is product quality. NE130/1 PEstring qualitycan be measuredusing the teststring stretchthread.Factors that influence the yarn are top roll diameter (A), distance of top back roll and top front roll, (B), distance clip thickness (C), and weight arms (D). Besides, there is an uncontrollablefactor namely room temperature. Initial parameters setting usedfor this stillvariesbecause ifduring the production processlaststhreadbreaks itwill changethe settings. For this combination,strength ofthe resultingyarnhas ahigh variationranged628to648gramsper piece. Taguchi method is applied to improve productperformance. Based on Taguchi method, the optimalfactor level combination is A2B2C2D2 (top roll diameter 28 mm, distance of top back roll and top front roll +1 mm, distance clip thickness 2.5 mm, and weight arms 14 kg/cm^2).

Key words –stringstretch, Taguchi method, factor level

I. INTRODUCTION

The string stretch qualityto be intimately linkedwiththe process of clothing made.The strings areless powerfulwilleasilybreak upso that it willaffectthe efficiency ofproduction. This requires theoptimization ofthe processof spinningtoincreasethe string stretch.NE130/1PEstring isa singlematerialcomprisesa mixtureofpolyesterandcottonwith acompositionratio of65percentand35percent.ValueNE130/1string stretchquality standardsaccording to theStandardIndustrialPEIndonesia(SII) issued by the Ministryof Industryisabove the610grams.Based on observations,the string stretch NE130/1PEtypes inone ofPTIndustriSandangNusantaraacquiredclothingindustrytensil estrength ofthe yarnis inthe range of628-648gramsper piece.This indicatesthat theproducthas met theSIIthread, butseen fromthe rangeobtainedvariancetensile strengththreadsarepretty big. This isoftendonedue tothe conversion ofRingSpinningmachineparameter settings.

Based on this,the companyneeds topay attention tostring spinningdraftlevel settingzonein order tominimizethe variation string stretch.It required anexperimentin order tobe able tosuppressthe variation string stretchthroughthe Taguchimethod ofexperimentaldesign.Application ofthe Taguchi methodcanminimizethe time andcost ofexperimentation.

II. LITERATURE REVIEW

A. *Definition ofQuality*

Qualityis the overallfeatures and characteristics ofa productor service thatcan satisfythe needs oftheir ability, whether explicitly statedordisguised(SNI 19-8402-1991)[2].

B. *Quality Control*

Quality control is definedas measurement process done in period of product and process design. Quality control involves every phase of product research and development, production process design and customer satisfaction.

Quality controlcan be divided intotwo parts:

1. Off line Quality Control
   Off linequality controlover theactivitiesrelated toproduct developmentanddesignprocess. The activitiescarried outare:
   a. Identification ofconsumer desiresandthe expectedconsumer
   b. Designingproducts that matchconsumer expectations
   c. Designingproductsconsistentlyandeconomicallyprofita ble
   d. Developclearandspecific enoughstandards, procedures, andequipmentproduction.

   Taguchiexperimentaldesignapproachintroducesusefulfor:
   a. Minimizethe variationin eachtarget value
   b. Designingproductsandprocesses, so the quality isrobust toenvironmental conditions
   c. Developproductorprocess sorobust tovariations inthe qualityof components.

   Robustmeans thatthe productorprocessconsistentlyare on targetandare relatively insensitive tofactorsdifficult to control.

2. On Line Quality control
   On linequality controlduring the productionprocessassociated with themaintenance andconsistencyof productsandprocessesthatminimizethe variationbetween units.

C. *TaguchiDesign ofExperiments*

According toTaguchi, there are twogeneralaspectsof quality ofquality of design andquality of thematch.Quality ofdesignis a variation ofthe existinglevel of qualityin a product thatwas intentional, while thequality of thematchishow wellthe productis in accordance withthe specificationsandclearancesrequired bythe design.Taguchi methodusesa set ofspecial matrixcalledOrthogonalArray.Thisstandardis a stepmatrixto determinethe minimumnumber ofexperimentswhichcanprovideas much information aspossibleall factors affectingparameters.The most important partof theorthogonalarraylies in theselection of a combinationofthe level ofthe input variablesfor eachexperiment[3].

Taguchi philosophy consists of three concepts, they are [4]:

1. Quality must be designed into the product and notonly checking the product. The best quality can bereached by minimizing deviation of target.
2. Product must be designed so that robust fromuncontrollable environmental factors.
3. Quality cost must be measured based on deviationfunction from the target and loss must bemeasured for all system.

D. Signal-to-Noise Ratio (SNR)

SNR is logarithm of quadratic loss function and used to evaluate quality a product. There are three SNR types, they are:

1. *Smaller-the-Better* (STB)
   Quality characteristic where by smaller value it gets, thebetter quality it has, however the biggest SNR is usedto determined optimum factor level[1].SNRequationwithquality characteristicsSmaller-the-Better is

$$\text{SNR STB} = -10 \log \frac{1}{n} \sum_{i=n}^{n} y_i^2 \quad (1)$$

   with n = number of trial
   y_i = response value of sample i

2. *Larger-the-Better* (LTB)
   The bigger value it gets, the better quality it has.SNRequationwithquality characteristicsLarger -the-Better is

$$\text{SNR LTB} = -10 \log \frac{1}{n} \sum_{i=n}^{n} \frac{1}{y_i^2} \quad (2)$$

3. *Nominal-the-Best*(NTB)
   Quality characteristic where by a nominal value (target) isdetermined. The closer value to the target, the betterquality it has. The S/N ratio function is

$$\eta = 10 \log\left[\frac{\mu^2}{\sigma^2}\right] \quad (3)$$

   with $$\sigma^2 = \frac{\sum (y_i - \bar{y})^2}{n - 1}$$

Furthermore, the Taguchi methodcan be divided intotwo types, namelysingle responseand multiresponse. Taguchi methodwithsingle responsehas only oneresponse variable, so thatan optimumcombination offactor levelscan be obtaineddirectly. Taguchi'smulti-response involves morethan oneresponse variableand eachresponse variablecouldyielddifferentcombinations offactor levels. Twomethods can be usedto solve theproblem ofmulti-response Taguchimethod isa MultiResponseSignalto Noise(MRSN) andTechniqueforOrderPreferencebySimilaritytoIdealSolution (TOPSIS) to determine theoptimal conditionson the stages ofthe designparameters.[5].

III. EXPERIMENT DESIGN

A. *Experiment Planning*

Planningstages ofthe experimentis thedeterminationof informationin conductingexperiments. The stages ofexperiments conductedis:

1. Selection ofthe tensile strength quality characteristics
   Tensileyarnquality characteristicssaid to be goodif it hasa highstrengthpulltest.
2. Identified and selection ofthe factors thatinfluence thequality characteristicsof yarntensile test.Based on the observations, there are fourfactorsof controlandtheuncontrollable factorsthatinfluencetensilestrength ofthe yarnspinningmachines, namely:
   a. top rolldiameter (A)
      Levelused is27mmand28 mm
   b. top back rollandtop front rolldistance (B)
      Levelthat allowsisbetween-1mm to+1mm.
   c. clipdistancethickness(C)
      Levelused isbetween2.1 mmto 2.5mm.
   d. weight arms (D)
      Levelthat allowsisbetween10kg/cm^{2}and 14kg/cm^2.
   e. room humidity(E)
      It is noise because this factor cannot be controlled.

B. *Experiment Execution*

This experimentis intendedto minimizethe variation string stretch testas a result ofthe frequent occurrence ofthe conversion ofring spinning machineparameter settings.String stretch quality testperformedinthe laboratoryof PTIndustriSandangNusantaraSecang, Magelang. The measurement resultsare presentedin TableI.

TABLE I
TENSILE STRENGTH TEST DATA

					Outer Array	
				E	1	2
	L8 OA (Inner Array)				Experiment Data	
	A	B	C	D		
	Column Number				Y	
Trial	1	2	3	4		
1	1	1	1	1	607,00	610,00
2	1	1	2	2	594,00	598,00
3	1	2	1	2	610,00	601,00
4	1	2	2	1	617,00	615,00
5	2	1	1	2	621,00	609,00
6	2	1	2	1	624,00	623,00
7	2	2	1	1	631,00	632,00
8	2	2	2	2	635,00	638,00

C. *Result and Discussion*

1. Normally test
   By using Barlett's test, the string stretch test data follow normal distribution, because χ^2_{cal} is – 0.3727 less than χ^2_{table} (3.8414).
2. Homogeneity and Analysis of Variance (ANOVA)
   Data is homogeneous, becauseχ^2_{cal} is0,0254 less thanχ^2_{table}(3,8414). Analysis ofVariance(ANOVA) givesthe factorsthat influence thestring stretch qualityin a rowistoproll diameter, distance between ofthe top frontroll andtop backroll, weight arm, anddistanceclipthickness.
3. SNR
   SNRstring stretch testsare presentedin TableIIandfactoreffectsare presentedin TableIII.

TABLE II
MEAN AND SNR STRING STRETCH

Trial	Mean	SNR
1	607	55,6851
2	594	55,5048
3	610	55,6416
4	617	55,7916
5	621	55,7763
6	624	55,8967
7	631	56,0075
8	635	56,0759

TABLE III
RESPONSES OF FACTOR EFFECT

Level	Controllable Factor			
	A	B	C	D
1	55,85	55,72	55,78	55,66
2	55,94	55,88	55,82	55,75
Difference	0,28	0,16	0,04	0,10
Rank	1	2	4	3

Conclusion: The optimumcombinationisA2B2C2D2. The optimum conditionbasedon theeffect ofthese factorsis a combinationof factorsthat have beenexperimented, so it is notnecessaryfor theprediction ofthe combinationof these factors.

V. CONCLUSIONS

1. Factorsaffecting thetensilestrength ofthe yarnis toproll diameter, distance between ofthe top frontroll andtop backroll, weight arm, anddistanceclipthickness.
2. TheoptimumfactorlevelcombinationisA2B2C2D2(top rolldiameter28mm, the distancebackroll witha rolltopfonts+1mm, thickness of2.5 mmand thedistancecliparmsweight14kg/cm^2). It cansuccessfullyimprovequality.

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