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쇽옵서버 피스톤로드 제조공정에 대한 공정관리 시스템 개발

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Development of a Process Management System for Shock Absorber Piston Rod Manufacturing

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쇽옵서버 피스톤로드(shock absorber piston rod)는 자동차의 충격과 진동의 흡수에 작용하는 자동차 현가장치(suspension equipment)부품의 일종이다. 피스톤로드는 자동차 충격흡수에 매우 밀접한 영향을 주기 때문에 제조에 있어서 고도의 정밀도와 표면 매끄러움이 요구된다. 피스톤로드의 제조공정은 선삭, 홈가공, 밀링, 전조 등 여러 공정으로 구성되는데, 여기서 품질불량에 가장 크게 영향을 주는 공정은 선삭공정(lathing process)이다. 이는 선삭공정의 가공공구(insert component)가 주원인으로서 반복되는 가공으로 인한 공구의 마모(abrasion)나 파손(breakage)이 주요 원인으로 지적되고 있다. 따라서 가공 데이터를 수집 · 분석하여 공구의 교체시기를 파악한다거나 가공 부품의 측정 데이터가 관리도 상하한선 내에 있는지 등 가공 공정 전반에 대한 체계적인 공정관리 시스템 개발이 요구된다. 본 연구에서는 자동차 쇽업서버 피스톤로드 제조공정의 가공 정보를 체계적으로 수집하여 관리하고 분석하는 자동차 쇽업서버 피스톤로드 제조공정에 대한 공정관리시스템을 개발하는 것이 목적이다. 개발결과 피스톤 로드의 측정 치수 변화 및 불량발생을 측정, 감지할 수 있었으며, 본 시스템을 통해 가공공구의 치수오차를 보정(compensation)하고 공정의 불량발생을 조기에 방지 함으로써 불량률은 1/5로 경감하고 작업자 수도 1/2로 감소시킬 수 있었다.

Keywords : Shock Absorber Piston Rod, A Statistical Process Control System, Compensation

1. Introduction

The shock absorber piston rod is an essential part of the suspension equipment that absorbs the shock and vibration of an automobile. Because it greatly affects shock absorption, a high level of precision and smoothness is needed. <Figure 1> shows the form of a shock absorber piston rod. At present, the lathing process is the main cause of errors in preciseness and smoothness of piston rods. This is because the piston rod processing tools often break and cause abrasion on the rods.

Therefore an automatic process control system must be developed to constantly measure and manage the lathing process for preciseness and smoothness[1, 2]. In this study we explore the development of a statistical process control system (SPC)

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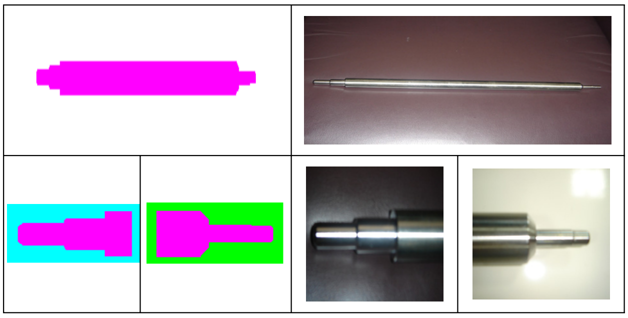
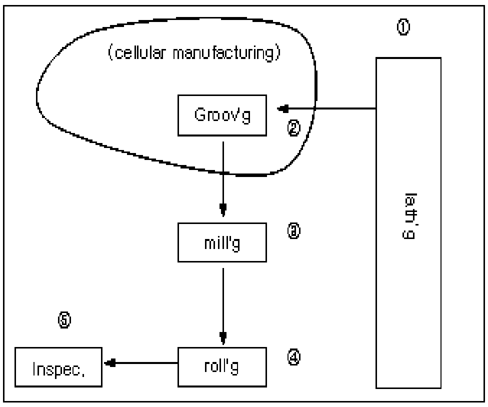
which can perceive the errors early and compensate for them [5, 7].



<Figure 1> Shock Absorber Piston Rod

2. Needs of Study

The shock absorber piston rod manufacturing process includes lathing, grooving, milling, rolling, inspection and finally packing as seen below in <Figure 2>. Lathing, which is performed 2 or 3 times, is for the forming of the main of the piston rod. Grooving is for equipping the stopper to determine the condition of a stroke. Milling and rolling are for equipping and assembling the shock absorber [10, 21].



<Figure 2> Piston Rod Manufacturing Processes

The error rates level affects as much as 71% of the net profit of the company relevant to this study, so process innovation is needed as seen below in <Table 1>. As previously mentioned, the lathing process as a weak process has the highest error rates among all the processes because the piston rod processing tools of lathing process often break and cause abrasion on the rods[11], [13], [16]. The statistical process control system (SPC), which has been developed for process management in this study, has the necessary functions to perceive errors early and record and analyze them. And it completely examine every part of the rods from beginning to end. This system can also estimate the needed changes in size and then automatically compensate and exchange tools for the lathing process.

<Table 1> Subject Company Profit Loss for 3 Years (2003~2005)

Items	2003	2004	2005	Total
Amount of Sales(A) / million	5,694	9,713	15,206	30,613
Net Profit(B) / million	100	206	693	999
Cost Loss Due to Error(C) /million	120	210	380	710
C/A (%)	2.1	2.1	2.5	2.3
C/B (%)	120	102	58	71

Therefore we make a plan of innovation to improve the problems for lathing process as seen below <Table 2>.

<Table 2> Plan of Process Innovation

Problem	Phenomenon	Innovation Plan
Difficulty in measuring and a lot of time for measuring	Incomplete inspection Negligence and error in inspection	Manufacturing of Total Inspection Tool
No prompt inspection	No early perception of error	Prompt inspection
No record for inspection	Impossibility to document factors and time of error	Inspection data storage in real time
Manual compensating by workers	No timely compensation	Compensation with automatic Tool
No process monitoring	Impossibility to estimate change in rod size	Display of the changes in size and process

3. Developing Contents

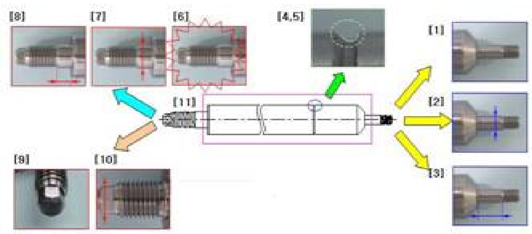
First, we must develop the measuring tools for the manufacturing process. We do this by defining a number of measured points on the rod, then by considering the characteristics of these points. Next, we must design appropriate tools to match the characteristics of the points. Here, measuring tools and measuring methods are needed for guaranteeing the precision and being appropriate for automatic measuring. There must be few errors in the function of R&R (Repeatability and Reproducibility). The SPC details of development, including the contents of the measuring tools and the measuring method, can be seen in <Table 3> [20].

<Table 3> SPC Details of Development

Items		Contents
Manufacturing of Measurement Tools	Places	Defined significant measuring points
	Measuring method	Choice of methods which is most appropriate for automatic measurement
	Tools	Tools which are appropriate for automatic measurement
Data Input/Output System		Data communication method and programming program
Display System		System displaying data and errors
Tool Compensating Program		Manufacturing Tool Compensating Program
Data Storing System		Inspection of Data and Data Storing Program

3.1 Plan of Measured Points

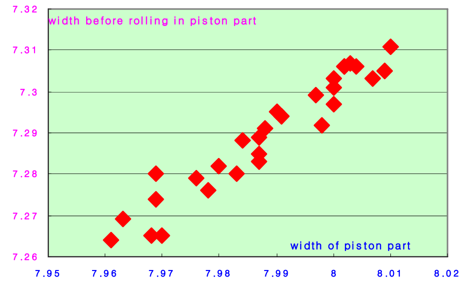
There are 11 measured points on each piston rod as seen in <Figure 2>. We discovered the strong correlation of 0.96 between the width of the host part and the width of the piston part as seen in <Figure 3>. The strong correlation shows that the two widths are dependent on each other. Therefore when we measure the width of the host part we can manage the size of the total width. The error rate of widths for the other parts are very low based on the examination profile of theirs.



No.	ITEM	No.	ITEM
[1]	shape of piston part	[6]	shape of host part
[2]	width of piston part	[7]	width of host part
[3]	length of non-rolling of piston part	[8]	length of non-rolling of host part
[4]	shape of grooving	[9]	shape of milling
[5]	omission of grooving	[10]	width of milling
[11]	shapes of the others	-	-

<Figure 2> Shock Absorber Piston Rod Inspection Points

Coefficient of Correlation :0.96



<Figure 3> Correlation Analysis

For length of the piston rod, its error rate is so high by 1.17% as it needs inspection process. With this, the inspection points are defined as 2 points which are the width of the host part and the length of the piston rod [3].

3.2 Method and Tools of Measuring

The condition of technology we develop for precision, repeatability and reproducibility(R&R) etc. are as seen in <Table 4> [18].

The air micrometer is best for measuring width and the electrical micrometer is best for length if we consider precision, region, cost and maintenance. See <Table 5> for an analysis of measuring tools [4].

<Table 4> Conditions of Measuring Tools

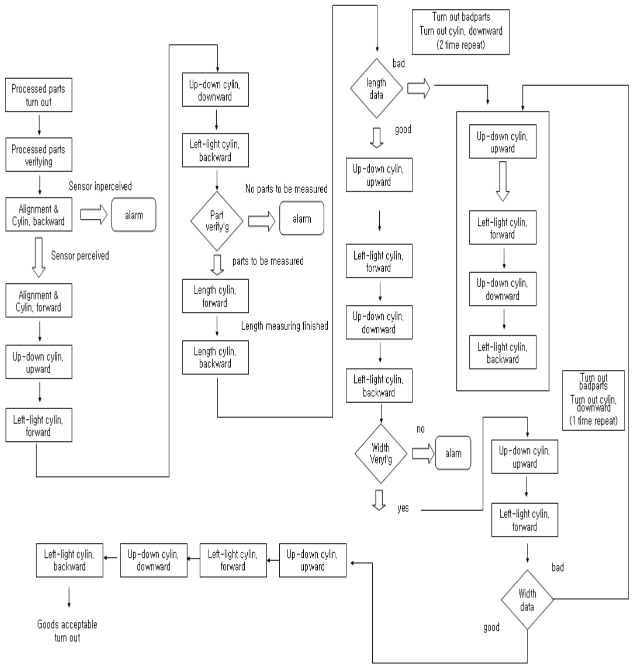
Items	Specification
Precision	width : 0.0005mm, length : 0.001mm
Data Printing	Printing available
Repeatability and Reproducibility	width : 0.001mm length : 0.005mm
Method of Measuring	Automatic measuring and computing available

<Table 5> Analysis of Property of Measuring Tools

Measuring Tools	Width				Length			
	Pre-cision	Range	Cost	Main-tenance	Pre-cision	Range	Cost	Main-tenance
Laser Micrometer	Good	Good	Too high	Difficult	Good	Not good	Too high	Difficult
Air Micrometer	Good	Good	Average	Easy	Good	Not good	Proper	Easy
Electrical Micrometer	Partly good	Good	Proper	easy	Good	**Good**	**Proper**	**Easy**

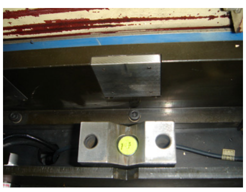
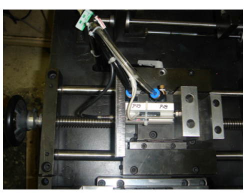
3.3 Measuring Actuators

<Figure 4> is the Flow Chart of Actuation. Based on the analysis of property of measuring tools as seen <Table 5>, measuring actuators of each air micrometer and electric micrometer to include alignment, transferring, measuring tools for length, measuring tools for width, pushing-out tools and the body are as seen in <Table 6> and <Table 7> [8, 9, 12].



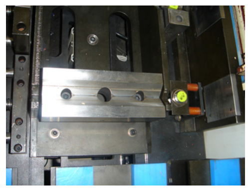
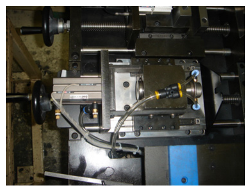
<Figure 4> Flow Chart of Actuation

<Table 6> Measuring Tool for Width

Picture	Key Parts	Specification/ Function
	Measuring length of V block and perceiving sensor	PR18-5DN (non-contact sensor, ∅18㎜, 5m covering)
	Measuring cylinder	CDQ2B12-25D-A73L
	Measuring probe	DP-10 (stroke 10㎜)
	Length control screw	TM-20 screw
	Length control handle and fixing bolt	Fixing measuring block
	Measuring block	Cross roller guide (VR4-80*7Z) equipped

Based as it is also on the analysis in the <Table 5> air micrometer and electric micrometer are applied to measurement for each the width of the host part and the length of the piston rod[14], [15].

<Table 7> Measuring Tool for length

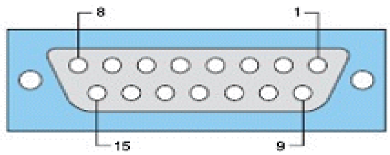
Picture	Key Parts	Specification/ Function
	Measuring width of V block and perceiving sensor	PR18-5DN (non-contact sensor, ∅18㎜, 5m covering)
	Measuring cylinder	CDM2F32-25A-C73L
	Measuring probe	O.D. 8.02 (out diameter 8.02)
	Length control screw	TM-20 screw
	Length control handle and fixing bolt	Fixing measuring block
	Measuring block	Cross roller guide (VR4-80*7Z) equipped

3.4 Tools of Data Computation

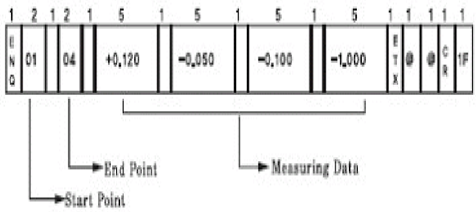
Tools of data computation include the data communication tools, the communication program and the data management system which transmit and record data. The specification data computation is as seen in <Figure 5>.

Data communication program has the function to save the data automatically in real time and can support 39port as the serial port. There is also a function of port setting to choose the baud rate and data bit. The composition of communication files and screen is as shown in <Figure 6>.

The data management program is for utilizing and recording measured data. The operating system is Windows XP, with a multi-port for enlarging the port. Data is saved as a text file (or CSV ; comma separated value file). This file can be used in EXCEL. EXCEL is a general program and is used for the sake of convenience. Through the data, the information of goodness and badness of parts and the data trend can be perceived[22, 23].

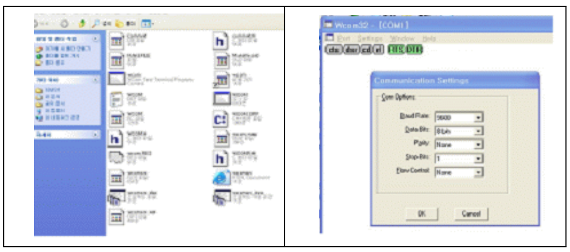


NO	명칭	Level	설명
1	NCOM	0 V	Ground
2	PCOM	24 V	Power
8	START	H/L	측정
10	READY	H/L	대기
13	NG	H/L	불량
14	OK	H/L	양품

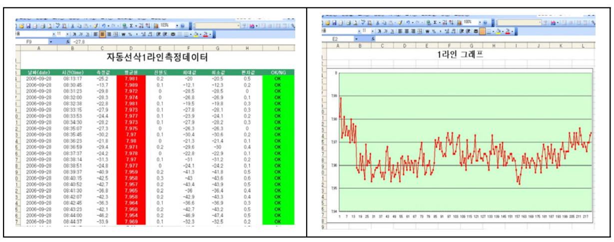


- Interface : RS−232C
- Port : Serial (9pin)
- Method : Asynchronous
- Character : Data bit = 8bit, Stop bit = 1, No parity bit
- Baud rate = 9,600bps

<Figure 5> Data Computation System



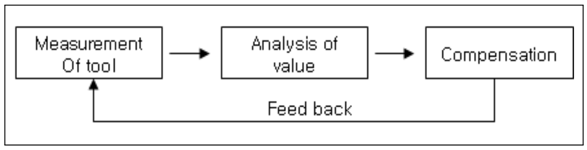
<Figure 6> Screen for Data Communication Program



<Figure 7> Screen for Trend of Data Change and Management Program

3.5 Automatic Tool Compensating Program

When the size of a rod is changed due to the abrasion of the insert tools, the program manages the size on the value of X and Y and measures the changes of length and width caused by the tools. This program is considered the G code by macro, which is used in CNC lathing and configures the limit values for tool compensation by modifying the parameters. The process of data feedback is as seen <Fig. 8>.



<Figure 8> Process of Data Feedback

3.6 Display Tools

Display tools visually show the value of length and width. They display the value of the goodness or badness of parts. When abnormal things happen, an alarm and buzzer start working for workers. The alarm can be heard even at a long distance

<Table 8> Analysis of the Results

Items	Units	Before	After
Number of workers	Person	4	2
Number of inspectors	Person	2	1
Error rates	%	2.5	0.55
Amounts of average production a day	Unit	14,400	17,000

4. Conclusion and Further Study

In this study we considered developing the SPC (Statistical Process Control) as a process management system which can measure precision changes and perceive the occurrence of errors early through monitoring, and then compensate for errors in the shock absorber piston rod manufacturing process. For this we developed the actuators, the computation system and a compensation system. As a result, we reduced the error rates by1/5 and greatly lowered the amount of work for employees as seen below in <Table 8>. For further study, we need to consider the scalability and integration of the system and to consider a simulation study which concerns the trade-off between cost and efficiency [6, 17, 18, 19, 24]. Based on this simulation we can build a more efficient manufacturing system.

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