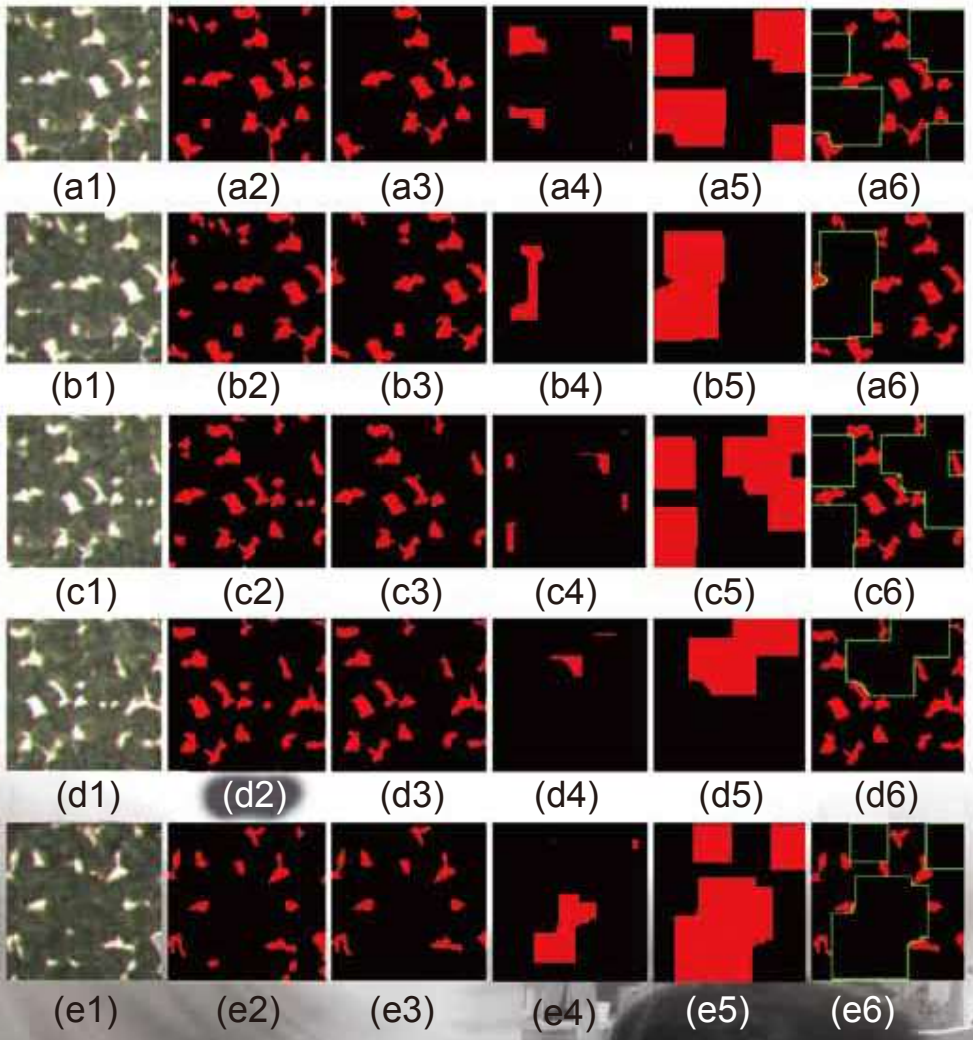
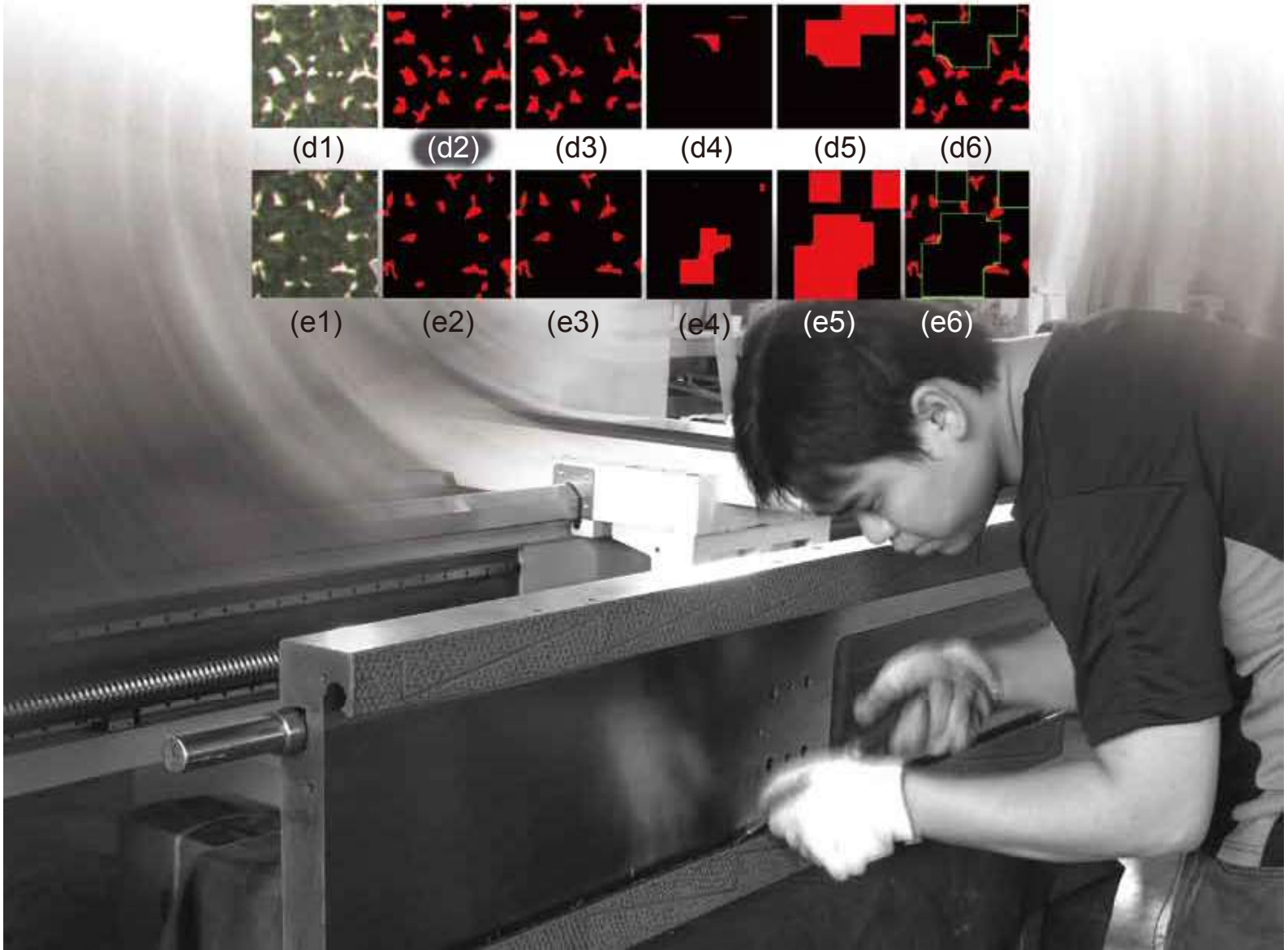
Quarterly 2011 VOLUME 3 ISSUE 11

The CHALLENGER

Global quality and service system of metal working industry





New logo announced

MICROCUT
THE CHALLENGER

is a professional , distinctive trademark for legal entity to identify that our machine with a unique, innovation symbols design. Microcut continuously performs service spirit to refresh customer impression with machinery manufacture for step in high position of global marketing promotion.

Customers' demand and distributors' comment are our first priority to develop environmental-friendly machine tool discovery with advanced technology. Microcut has been devoted to machine building for several decades with rich experience of machinery research & development.

Beneath strong dealership cooperation, we desire to restore another peak of company reputation and unveil a brand new identity that represents another significant milestone in exploring world-wild marketing.

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Shanghai Attraction

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Welcome user's submission

of company profile, sharing Challengers' Products experience and pictures of people, products. Please send your story and pictures (images in high-resolution higher than 300 dpi) to your Challenger Factory Outlet or e-mail to t02@mail.buffalo.com.tw
Only English version is acceptable.

From the Publisher

The value of job is defined in different ways. People usually get jobs and salaries to live on and regard works as a particular form of transaction. Therefore, people tend to input the least investment and the easiest way to complete work. The author defines jobs in three levels. The first level is a consideration of human relationship. Second is commitment, and the third, the highest level, is the motivation as regard to the self-actualization.

The third level, the motivation of self-actualization, is believed to be the most acceptable reason for people to devoting themselves into works. The definition of quality and value of their jobs should therefore be considered to co-exist with this. If we agree with the definition, then the concept of job is no longer limited to a consideration of relationship, commitment and responsibility. The outcomes of jobs or missions should represent one's abilities, credit, quality, reputation, and his human value. Thus, people should consider the meaning of jobs as working for themselves, as well as existing for their own human value of life.

After working in the field of metal working machine industries for more than 35 years, it is interesting to see the difference of those persons who have worked 35 years ahead of my time in the business management field and find out what will be the news in further decade. One thing clear is that the great challenge in the last 30 years grows us a lot, and we remain fighting for a better future. I will be very surprised if the next generation or two are lucky enough to experience so many times of challenge from the global finance crisis and recession of the industries.

It was once the generation when operators using the punching machine to write the program for a Numerical Control(NC) machine, the job passion leads the big step of Computerized Numerical Control (CNC) products which was found to improve the productivity a lot. Because of the motivation of self-actualization, people have never been satisfied with the working quality, speed and reliability, so a lot of studies of mechatronics technology had been discussed and a much higher revolution and feed speed been introduced, a multiple axes simultaneously machining capability been taking over the traditional 2 axes working. All these improvements happened in such a short 30 years, which we have been so lucky to experience. Though it is such a great one, it hasn't come to the ending point yet, as we need to be better, improving the reliability and human's job quality.

"The global finance is facing a new unstable situation," said the IMF President, Dr. Christine Lagarde, we still trust EU is going to be a mighty finance unit to support a stable European finance, but it seems like that this is much more risky than its original idea. And it is so hard to get most of the EU countries to become a conclusion while few countries are facing their weakness. The concept of one currency for multiple countries seems not so easy to pass the difficulty as it was. Certainly it is judging the royalty from each area or countries, but one thing clear which is that we are having more difficulty to expect a better economy to be shown in short. It could be even worse, that one more global finance crisis raised, then it will be a nightmare to most of the machine tool builders and distributors. I am sure that our industry should be alone.

At this stage, what we can do is to strengthen the company, improve the human job quality and make sure that we will be the better one in long term.

Dr. Paul Chang
Aug, 2011

Overseas Distributors Training Course

12 engineers from 6 distributors joined HBM-4T/5T installation training course hold separately on Feb. 7-11 and June 13-17, 2011. Also, many distributors reported that they could not join the training courses on account of the current high pressure of their own activities. This shows that our distributors from very different countries have great deal of work in hand.

In June, Distributors' technicians coming from U.K., Germany, Australia, and Austria join the courses of practical maintenance procedures on T-type horizontal borer in our number 8 factory which particularly features for boring machines. In February, a group of 7 engineers from China had the same courses on the first working day after the Chinese Lunar year holiday since there were 4 machines waiting for installation right after the holiday. Also, they could only get these dates free while their clients are still on holiday.

During the in-house training, many important subjects are demonstrated and discussed. The major courses are the machine installation procedure, foundation alignment, dynamic accuracy & assembly, controller operation demonstration, electric diagram study, and parameter setting practice on both Heidenhain and Fanuc controller. In the first day, each person worked on a HBM-5T to conduct a machine foundation alignment. This took long hours as the foundation is the most important factor to ensure the machine accuracy. In the 3rd day, everyone worked on the machine table disassembly and re-assembly to practice table replacement. In the last day, everyone passed the examination and got the certificate.

Photo story: Mr. George Buchel from company VOLZ and Mr. Anton Rusche from company Franz Moser are kneed on table to check table leveling.

Photo story: Mr. Darren Goldring tried to assembly the worm shaft of table transmission system. Table was just re-assembled on this machine.

Overseas Distributors Training Course

Date.2011.06.13-2011.06.17

context
(1) Mechanic maintenance (HBM-4T/5T)
(2) Controller is major in HEIDENHAIN & FANUC

Detail classes:

DATE	SUBJECT	DETAIL		TRAINER	TIME
6/13	Company tour/ Course discussion	教育訓練說明與討論(各區實務) Itinerary discussion 相關人員介紹 Staff introduce 學員介紹 Joiner introduce		Sales representative +Richard/Eric/Alan/ Yang/Gary/Ian/Eugene/ David	0830-0930
		公司簡介 Company profile		Angle	0930-0950
		廠區參觀 Company tour		Leo + Richard	0950-1200
	LUNCH				1200-1300
	Main body assembly 本體組裝	X/Z軸底座安裝/Y軸立柱安裝/主軸安裝/配件安裝/安裝油壓配重及鈑金 /電氣箱/配線槽安裝說明/ATC組裝 Assembling instruction of X&Z axes base/Y-axis column/Spindle /accessories fitting/Hydraulic counter weight & sheet metal/electric cabinet/cable channel/ATC		Richard/Alan/Yang	1300-1500
		REST			1500-1515
		地基圖面說明 Instruction of foundation			1515-1720
	DINNER				
6/14	dynamic accuracy and assembly 動態/校正/組裝	地基水平調整-實際操作 Practice of Foundation alignment		Richard/Alan/Yang	0830-0950
		REST			0950-1000
		地基水平調整-實際操作 Practice of Foundation alignment			1000-1200
	LUNCH				1200-1300
	dynamic accuracy and assembly 動態/校正/組裝	ISO精度檢驗及調整 ISO checking list & adjustment		Richard/Alan/Yang	1300-1400
		REST			1400-1410
		ISO精度檢驗及調整 ISO checking list & adjustment			1410-172000
	DINNER				
6/15	dynamic accuracy and assembly 動態/校正/組裝	ISO精度檢驗及調整 ISO checking list & adjustment		Richard/Alan/Yang	0830-0945
		REST			0945-1000
		ISO精度檢驗及調整 ISO checking list & adjustment			1000-1200
	LUNCH				1200-1300
	dynamic accuracy and assembly 動態/校正/組裝	ISO精度檢驗及調整 ISO checking list & adjustment		Richard/Alan/Yang	1300-1500
		REST			1500-1515
		ATC校刀 ATC alignment			1515-1630
		主軸頂刀量調整步驟 and OTT打刀油缸更換步驟及注意事項 Spindle tool rejection length adjustment and OTT cylinder			1630-1730
	DINNER				
6/16	dynamic accuracy and assembly 動態/校正/組裝	工作台拆裝/渦桿齒隙調整 Table maintenance & worm gear back lash adjustment		Richard/Alan/Yang	0830-1000
		REST			1000-1015
		工作台拆裝/渦桿齒隙調整 Table maintenance & worm gear back lash adjustment			1015-1200
	LUNCH				1200-1300
	Fanuc/Heidenhain Operation description 電器箱配置方式講解、操作講解/簡單故障排除	FANUC 1. Electric diagram 2.Setting manual	Heidenhain 1. Electric diagram 2.Setting manual	Gary/Ian/Trista (Heidenhain) Eugene/David (FANUC)	1300-1500
		REST	REST		1500-1515
		FANUC 1. Electric diagram 2.Setting manual	Heidenhain 1. Electric diagram 2.Setting manual		1515-1730
	DINNER				
6/17	Fanuc/Heidenhain Operation description 電器箱配置方式講解、操作講解/簡單故障排除	FANUC 1. Electric diagram 2.Setting manual	Heidenhain 1. Electric diagram 2.Setting manual	Gary/Ian/Trista (Heidenhain) Eugene/David (FANUC)	0830-1000
		REST	REST		1000-1015
		FANUC 1. Electric diagram 2.Setting manual	Heidenhain 1. Electric diagram 2.Setting manual		1015-1200
	LUNCH				1200-1300
	TESTING	TESTING		Kim/Sabina/Eric/Alan	1300-1400
		REST			1400-1430
		Q & A-問卷調查 Q & A and Questionnaire			1430-1530
	Closing ceremony	Certificate		Paul+all	1530-1730
	DINNER				

Microcut

Certification

June 17, 2011

This is to Certificate that

Mr. Andrew Weber

has taken the following training courses during June 2011

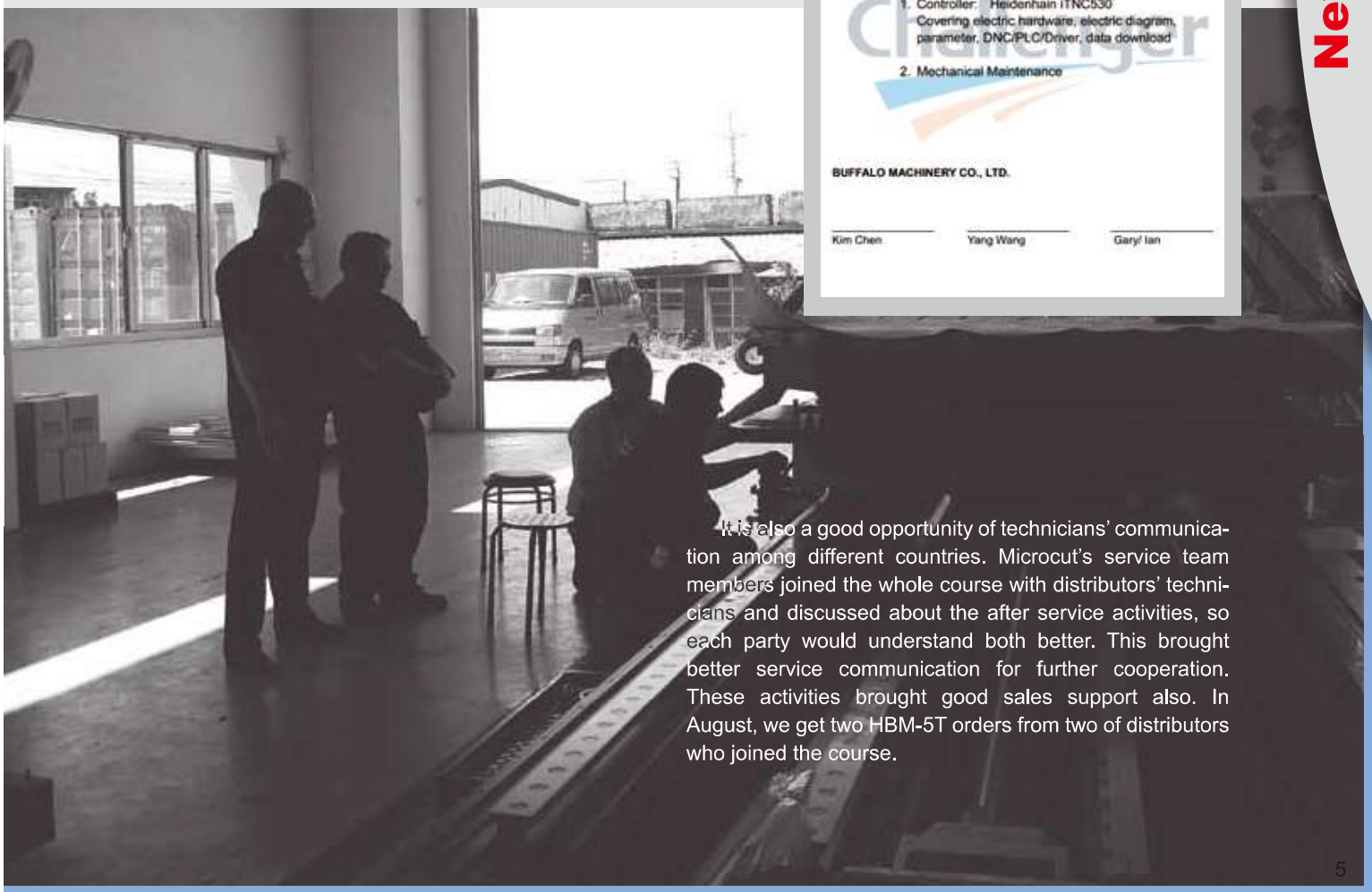
Model: HBM-5T CNC Boring machine

1. Controller: Heidenhain iTNC530
   Covering electric hardware, electric diagram, parameter, DNC/PLC/Driver, data download
2. Mechanical Maintenance

BUFFALO MACHINERY CO., LTD.

Kim Chen | Yang Wang | Gary Ian

Photo story: It is also hard work for technicians from overseas to work in such high humidity and high temperature although it's only early summer in Taiwan; clothes get wet and dried several times.



It is also a good opportunity of technicians' communication among different countries. Microcut's service team members joined the whole course with distributors' technicians and discussed about the after service activities, so each party would understand both better. This brought better service communication for further cooperation. These activities brought good sales support also. In August, we get two HBM-5T orders from two of distributors who joined the course.

Global Outlook Shanghai

Shanghai, people from China called “Paris of the Orient”, The city is the commercial and financial centre of China. She is the largest city by population in the People's Republic of China. Her modern, international and fashionable reputation attracts travelers and visitors from all over the world. People come to enjoy fantastic shopping and wide variety of entertainment or simply to experience the glitz of China's most cosmopolitan city.

Location

The city is located in eastern China, at the middle portion of the Chinese coast, and sits at the mouth of the Yangtze River, it has been considered as one of the most important ship port in China. The rapid growth of commercial activity over the last two decades, Shanghai has again become a global city, exerting influence over finance, commerce, fashion, technology and culture.

Climate

Shanghai has a humid subtropical climate and experiences four distinct seasons. Winters are chilly and damp. Nighttime temperature drops below freezing although there are couple days of snowfall in most years. Summers are hot and humid, with an average of 8.7 days exceeding 35 °C (95 °F) annually; occasional downpours or freak thunderstorms can be expected. The city is also susceptible to typhoons in summer and the beginning of autumn. The most pleasant seasons are spring and autumn.

Transportation

Shanghai is one of the leading air gateways in Asia. There are two airports which provide a well connection to the major cities in China and oversea, They are Shanghai Pudong International Airport and Shanghai Hongqiao International Airport. Pudong Airport is the main international airport, while Hongqiao Airport mainly operates domestic flights and some near Asian cities.

Shanghai is not only considered as the leading air gateways in Asia but also regarded as the hub of High

Speed Rail (HSR) lines in China. Notable examples of HSR lines in Shanghai include The Beijing–Shanghai High-Speed Railway, opened in June 2011.The non-stop train from Beijing South to Shanghai Hongqiao was expected to finish the 1,305 kilometers in 3 hours, 58 minutes, averaging 329 kilometers per hour, making it the fastest scheduled train in the world. The Shanghai Maglev Train, an airport rail link service opend in 2004, takes 7 min. 20sec. in between Pudong airport and Shanghai down town with the travel distance in 30km, it is one of the highest speed train in Asia which reaches the top speed to 431 km/h.

In Shanghai, an extensive public transport system, largely based on metros, buses and taxis which transports a huge amount of 20 million residents daily. Shanghai's rapid transit system, Shanghai Metro, incorporates both subway and light railway lines and extends to every core urban district and suburban districts. In 2010, there are twelve lines of metro which makes the service network become the longest one in the world. Payment of all these public transportation can be made by using the Shanghai Public Transportation Card.

There are three major railway stations in the city center, Shanghai Railway Station, Shanghai South Railway Station and Shanghai Hongqiao Railway Station. All three stations are designed to link to the metro network and serving as hubs. Moreover, she owns the world's most extensive bus system which is counted nearly one thousand bus lines. Also, Taxis are plentiful in Shanghai. In the city-center, there are several elevated expressways to lessen traffic pressure.

Global Outlook Shanghai

Economy and Industry

Shanghai is the commercial and financial centre of mainland China. This is exemplified by the Pudong District, which became a pilot area for integrated economic reforms. Today, Shanghai is again one of the most prosperous cities in the world and attractive to overseas investors. Shanghai is the center of finance and industries, she is now aiming to be a global finance core and international shipping center in the near future. In 2010, Shanghai's total GDP grew to 1.687 trillion RMB (US$256.3 billion) with GDP per capital of 76,000 RMB ($11,540).

The three largest service industries are financial services, retail, and real estate. The manufacturing and agricultural sectors accounted for 39.9 percent and 0.7 percent of the total output respectively.

Shanghai plays a key role in China's heavy industries, too. A large number of industrial zones are backbones of Shanghai's secondary industry. Heavy industries accounted for 78% of the gross industrial output in 2009. China's largest steelmaker and China's oldest shipbuilders are both located in Shanghai. Automobile industry is another important industry.

By 2020, the Chinese government is targeting that Shanghai will have a multi-functional and highly international financial center that comprises internationally competitive financial institutions and professionals.

Environmental protection

Public awareness of the environment is growing, and the city is investing in a number of environmental protection projects. The government also provides incentives for transportation companies to invest in LPG buses and taxis. Air pollution in Shanghai is low compared to other Chinese cities, but the rapid development over the past decades means it is still high on worldwide standards. The government has moved almost all factories within downtown to either outskirts of Shanghai or the neighboring Jiangsu and Zhejiang Provinces in the last two decades. In addition, several parks have been built in the city. As a result, Shanghai's air quality has been steadily improving since 1990s.

Above all, Shanghai, this China's most prosperous metropolis is often called "The city of the future". Behind the theme "Better City, Better Life," the municipality is setting an ambitious target to become an internationally acclaimed urban area which is boasting a harmonious lifestyle.

Distribution

Introducing one of the most successful distribution in global market - Shanghai Terna Mechanical & Electrical Technology Co., Ltd.

Shanghai Terna Mechanical & Electrical Technology Co., Ltd was found in Shanghai since 2003, Terna Company is a well known importer and distributor of CNC machines covering whole Chinese market. The major distribution items include table type CNC Horizontal Boring & Milling Machine, Heavy duty CNC Machining Center, Heavy Duty CNC Turning Machine and Floor type Boring & Milling Machine from. The company has become the exclusive distributor for Microcut/Challenger Heavy Duty lines of machines since 2008. Also, a good numbers of Horizontal Borer and Heavy Duty Vertical Machining Centers has been installed in the major cities or areas. The company has been servicing in many different major industries, such as oil industries, ships building, Molding and heavy duty machining shops.

Terna Company has a powerful team of skilled mechanical and Electrical technicians, providing the best service to support all the installed machines working under good and high productivity condition. The after sales service department consists more than 20 persons, all technicians are not only with well educated and experienced level, most technicians get technical certificate from Buffalo Machinery in the last few years. Service calls are responded within four hours, and service engineer is guaranteed to reach the end-user sites in twenty-four hours. For the customers in remote location, they will be at customer's premises in forty-eight hours. It is the key how the products been sold successfully in Chinese market.

There are more than 100 valuable clients in Chinese market, which is including high percentage of international well-known enterprises. For instance, Huangshan Wannan Machinery Co. Ltd., Shandong Himile Mechanical Science & Technology Company, Harbin Electric Machinery AC-DC Motor Company Ltd, Ha Electricity Group Jiamusi Motor Co. Ltd., MSP/DRILEX Equipment (Shanghai) Co. Ltd., and Lee Cheong Machine (Shenzhen) Co. Ltd. Most of these companies are either subcontractors of international firms or large scale companies in charge of international trade.

Terna's distribution area are not only located in North China (the main service is in the heavy duty industries and automobile production), Eastern China area (many of the green power industries) , South China area and South-west areas (many in mold and production field) but also takes part in Hong Kong and Macao. Moreover, the distribution net work is also involved in ship yard industry, aviation, railway service, Engineering service industry,

construction machinery, machine tool manufacturing, and die & mold industry.

Terna has built customers' satisfaction and loyalty by providing high quality products with reasonable price level, as well as a great experienced service team and its perfect after-sales service quality. Terna Company is expanding the scale of operations in China's vast market.

"There is no doubt that manufacturing plays an important role in every country's development and progress." said Mr. Xiang Dong, Xia, The President of Terna Company. "We have been committed to introduce advanced machines and equipments to our respected customers since the company's first started. We provide customers manufacturing technology, know-how of turn-key projects, and stand by customers with efficient after-sales service." Based on its well established quality brand names, many of the repeat orders are placed and a good number

Distribution

backlog order support a strong business up to middle of 2012.

After Service

After Service is the most important element of success in business. The excellent after service not only related to the integrity of the quality of products but also related to customer satisfaction of the products features. All in all, Mr. Xia from Terna Company believes “good quality, on time delivery and fast service” and adheres to the principle that “customer is supreme”.

KEY COMPONENT

INA calculation program - BEARINX®

SCHAEFFLER GROUP

INA monorail guidance systems are compact linear guidance systems that are supplied complete as standard and have high rigidity and load carrying capacity. They can support forces from all directions- apart from the direction of motion- as well as moments about all axes and can be supplied in various accuracies and preload classes. As a result, they are also suitable for applications with high guidance and positioning requirements.

The size of a monorail guidance system is determined by the demands made on its load carrying capacity, rating life and operational security. The load carrying capacity is described in terms of the basic dynamic load rating C, the basic static load rating C0 and the static moment rating M0x, M0y and M0z, Figure 1.

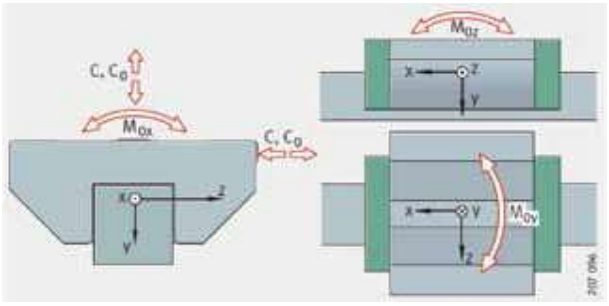


Fig.1 Load carrying capacity and load directions.

BEARINX® for precise design

In order to achieve precise design of linear guidance elements in relation to basic rating life and static load safety factor, it is necessary to calculate the bearing load in a statically indeterminate elements (Loading of individual rolling elements, shown as Fig. 2). This requires a complex calculation process. For this reason, INA developed the rolling bearing analysis program BEARINX® which can be used to calculate linear and rotary bearings as a part of the complete system (e.g. machine tool, automotive gearbox, etc.) and thereby ensure reliable designs.

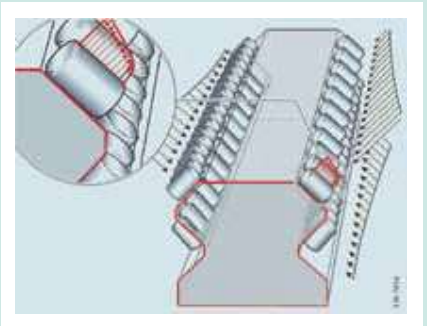


Fig.2 Internal load distribution under combined load

The liner module of BEARINX® can be used to calculate linear guidance elements in multi-axis systems (e.g. machine tools) under any load combination down to the level of the rolling element contact. The integral analysis method can be used to investigate the influence of nearly all parameters of the complete system on relevant results.

This sophisticated calculation model takes account of all the elasticity in the systems, ranging from the rigidity of the saddle plate and guideways through to the non-linear deflection behavior of the rolling elements.

In order to determine even more precisely the pressure between the rolling elements and raceway in linear recirculation roller bearing and guideway assemblies, the end profiling of the rolling elements is also taken into consideration. The adjacent construction is assumed to be rigid in the first instance but can, if necessary, be modeled on an elastic basis by means of reduced rigidity matrices (e.g. from FE calculation).

This model gives significantly more precise results than calculation programs that only take account of elasticity in rolling contact. This means an increased level of security in the design.

BEARINX® allows the calculation of systems with any number of: travel axes, linear guidance elements and linear drives, load situation, loads and masses. The results provide by BEARINX® include the static load safety factor, the basic rating life and the displacements that arise from the elasticity of the bearing arrangement.

The liner calculation program BEARINX® online assists in the calculation and design of the linear guidance system shown as Fig.3.

Fig.3 Example page from the online program

KEY COMPONENT

Franz Kessler

"FRANZ KESSLER, Germany with more than 600 employees, sees itself as a systems partner to machine tool manufacturers. By providing customer-specific solutions for turning, milling and grinding machines that are individually developed to meet the particular customer's needs Kessler has achieved a leading position in the market in the motor spindle segment. Three indispensable mainstays guarantee the success of Kessler's engineering: (1) the secure mastery of electric motor construction at the highest level of quality – from the draft through the calculations and design to production and testing; (2) the trouble-free integration of the motors into the environment of all the well-known CNC manufacturers; (3) the design of motors to meet the needs of the particular application.

In the area of synchronous technology Kessler has constructed lathe spindles capable of up to 1,000 Nm, and developed milling spindles, the most outstanding characteristics of which are the acceleration figures (0-10,000 rpm in 0.15 sec., 0-20,000 rpm in 0.60 sec.) and an extremely good power/weight ratio (80 Nm/80 kg).

The successful Kessler torque motor forms the basis with high dynamics, high torque and compact dimensions. The direct drive on all axes allows a surface finish, which can not be reached with mechanical drives. Various options such as table clamping, rotary union, high-precision positioning and large table payload enable minimum flexibility for modern, multi-axis machining centers.

Microcut MCG-5X with Kessler motorized spindle and torque table

Products

RAM type Horizontal Boring and Milling Machine

The HBM series horizontal milling and boring machine has been developed to provide a wider selection of working capability and it meets the needs of various potential. The large loading capacity working tables with V-travel and floor-type horizontal milling and boring machine are on the pipe line, that can be widely utilized in the energy industry, mining industry, oil & gas industry, and die & mold industry. The HBM F-series provide various dimension of larger working tables with greater load capacity and multiple types of boring heads that can be applied.

Except the model with working table type, Model HBM-4, a series of T-type HBM series have been developed, such as model HBM-4T,HBM-5T and HBM-5TE have been successfully service in the field. The RAM type, with two different support designs of heads will be available, which is the borer application type: TD- series and the milling type, TDM- series, have been developed successfully.

TD Hydrostatic supported Ram travel

A superior design of the ram travel is supported by a device of hydrostatic unit which ensure a rigid and stable working condition of the ram. Large size boring requirement and deep hole boring are the unique device to be.

TDM Heavy Duty Linear guide way supported Ram travel

A rigid roller guide way support ram is provided in this special mechanism, it provides a power support mechanism to offer a powerful milling capability. A fast machining device is provided. It ensures the application of milling and facing to be easy.

RAM Deformation and Compensation technology

The key point of development of the RAM type machines are structured mainly based on the high tensile strength capability of its design. The research technology in controlling the thermal expansion of spindle is a skill of optimization. The front and back of Ram contains two supporting guide ways that can perform a highly rigid and steady supporting structure, and the structure moves at high speed which meets the requirement of the needs for high speed cutting industries. Each structural part is based on the mechanism concept of heavy duty machine, with provide high tensile strength of the rib structure, the series product are also equipped with excellent stable quality of vibration supervision resistant.

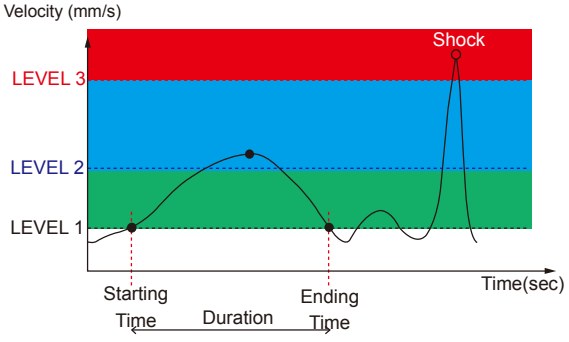
Spindle Vibration Supervision

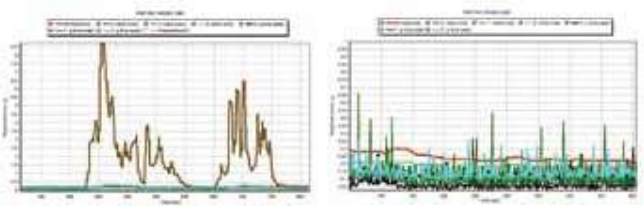
The spindle is equipped with Spindle Vibration Supervision (SVS), of which the main function is to adjust the spindle speed which is based on the vibration of spindle, and can decrease the corrosion of the spindle and cutter during the manufacturing process. The irregular vibration alert is set to be 3 stages alert to further improve the lifespan of the cutter and spindle. Three levels for spindle vibration monitoring:

First level: The warning message appears when the abnormal vibration occurs.

Second level: The error message appears and reduces spindle speed and feed rate.

Third level: When the vibration exceeds10mm/s, it is assumed that there has been a collision with the spindle and the machine should automatically shut down to prevent any further damage after the collision.





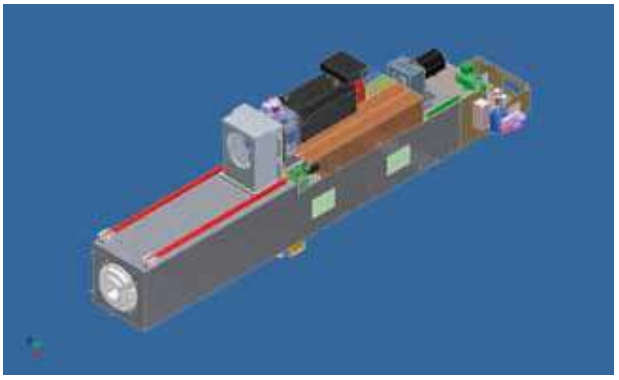
Vibration Monitoring and Analysis

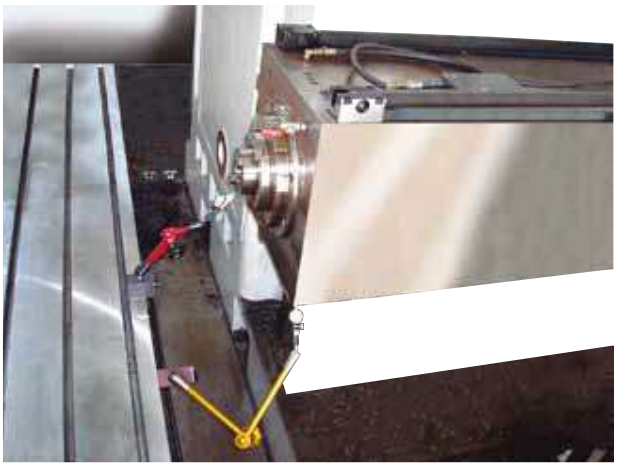
As shown in the chart, the vibration values measured via a highly sensitive vibration sensor will monitor the vibration values, when it is out of range for certain period of time continuously. The microprocessor can record up to 12000 data, which is enough for the technician to analyze vibration history and save the time to find the fault. This function increases the life span of the spindle while reducing the vibration on spindle.

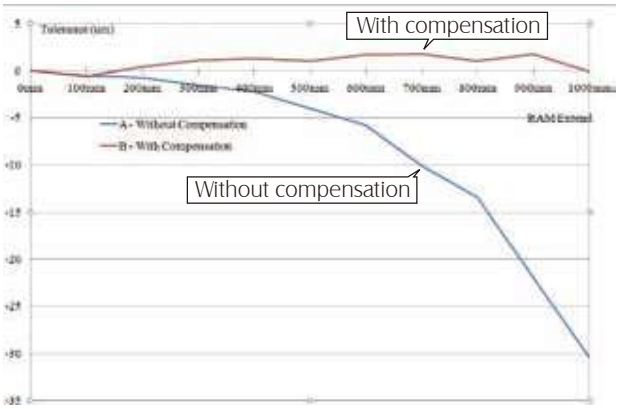
34	Over V Begin	2008/01/05 14:10:32	V=6.221 mm/s (rms)
35	Over V End	2008/01/05 14:10:48	T=33.24 °C
36	Over V Begin	2008/01/05 14:10:55	V=10.150 mm/s (rms)
37	Over V End	2008/01/05 14:11:02	T=33.64 °C
38	Over V Begin	2008/01/05 14:11:22	V=35.409 mm/s (rms)
39	Over V End	2008/01/05 14:11:24	T=34.05 °C
40	Shock	2008/01/05 14:11:26	17.414 g (true-peak)
41	Over V Begin	2008/01/05 14:11:36	V=49.327 mm/s (rms)
42	Over V End	2008/01/05 14:11:39	T=34.20 °C
43	Over V Begin	2008/01/05 14:11:46	V=46.719 mm/s (rms)
44	Shock	2008/01/05 14:11:50	19.535 g (true-peak)
45	Over V End	2008/01/05 14:11:55	T=34.31 °C
46	Shock	2008/01/05 14:11:56	17.781 g (true-peak)
47	Over V Begin	2008/01/05 14:12:01	V=27.463 mm/s (rms)
48	Over V End	2008/01/05 14:12:09	T=34.42 °C
49	Shock	2008/01/05 14:12:10	15.130 g (true-peak)
50	Over V Begin	2008/01/05 14:12:18	V=50.368 mm/s (rms)
51	Shock	2008/01/05 14:12:21	10.291 g (true-peak)
52	Over V End	2008/01/05 14:13:12	T=35.45 °C
53	Shock	2008/01/05 14:13:14	10.386 g (true-peak)
54	Over V Begin	2008/01/05 14:13:43	V=46.625 mm/s (rms)
55	Over V End	2008/01/05 14:13:49	T=35.75 °C
56	Shock	2008/01/05 14:13:49	18.148 g (true-peak)
57	Over V Begin	2008/01/05 14:13:54	V=43.425 mm/s (rms)
58	Over V End	2008/01/05 14:14:05	T=35.86 °C
59	Over V Begin	2008/01/05 14:14:09	V=39.942 mm/s (rms)
60	Shock	2008/01/05 14:14:20	20.609 g (true-peak)
61	Over V End	2008/01/05 14:14:20	T=36.00 °C
62	Over V Begin	2008/01/05 15:07:59	V=34.467 mm/s (rms)

RAM Deformation Compensation Function

RAM deformation and compensation uses the hydraulic sector to pull the Ram in time. When the Ram extends, the effect of gravity would cause the Ram to sag, and the hydraulic cylinder would exert and create an opposing pulling force, and would pull the Ram back. When hydraulic pressure is being transferred to the hydraulic cylinder to resist the effects of gravity, the installed pressure feedback device can conserve the transferred pressure. The hydraulic pressure output is good for detect and get the compensation of the pressure feedback device to calculate the value required.







Products

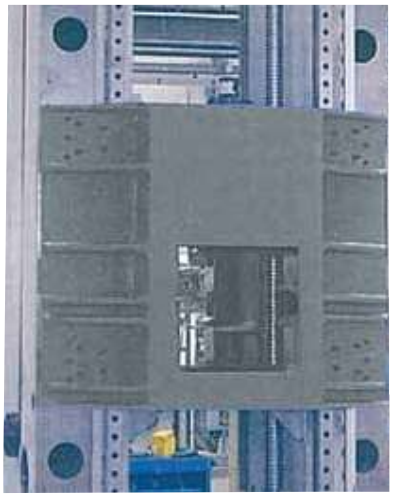
Z-axis Structure

The Z-axis base provides 3 rigid linear guide ways for heavy duty loading requirement and fast movement. The main frames are made of high grade Meehanite licensed Steel to ensure the rigidity of the structure. Precise C3 class ball screw design can guarantee the axial and radial heavy cutting strength.

Y-axis Column Structure

The column guide utilizes box way design, the guide surface has been processed with induction hardened and ground procedure, and the bearing surface hardness is HRC50°. The box guide ways are convenient for manufacturing tall work pieces because of its high tensile strength design that can prevent any vibration at the end of the column during the manufacturing process.

Hydrostatic type



Linear guideway type

X-axis Structure

High grade Meehanite licensed steel has been treated by induction stress relief process has high vibration resistance and can perform better vibration absorbing than normal cast iron, increasing the stability of the machine. Oil and coolant are recycled on each axis to prevent any pollution problems and would fit any environmental standards. The axial position utilizes absolute encoder to increase the precision of each manufacturing point, and because of the absolute encoder, the home position step can be removed and shorten cycle time.

Heavy loading Working Table

The working table surface has been designed for heavy-duty machining; a high precision encoder guarantees the tolerance. The double pair of planetary gear structure can guarantee the low tolerance of the bi-direction backlash which is suited for continuous processing needs.

The rotating surface has been treated through a series of strict precision hand scrapping process. It is guaranteed that the contact points of the bearing surfaces are smooth, and ensure there are min contact points for16-24 points per square inch, allowing the lubricating oil to evenly spread leaving the error in an ideal range. Any sliding guide ways have been casted with high quality and durable material, the driving gears were processed to be durable, guaranteeing the superiority of the precision.

The structure can be sure that the braking system precisely control, but can also be sure to support the manufacturing and its axes force. A complete lubricating design can guarantee the smooth processing of the working table under the normal loading condition. When the load is below 40 metric tons, the strong injection Lubrication system is utilized, and when the load is above 40 metric tons, the hydrostatic system is utilized. The bi-directional gear driven system provide backlash compensation capability.

Application 5-axis Milling

In the aircraft industry, the production of highly stressed work-pieces involves the machining away of a high proportion of material. With 5-axis machining of structural components, up to 90% of the raw material can be removed during machining. This calls for extremely high metal removal rates, which can only be achieved with highly efficient HPC machines. High-quality engine parts are also increasingly milled from the solid (BLISK). In this case, the emphasis is more on maximum dimensional accuracy and surface quality rather than machining capability.

The control systems used in 5-axis machining centers must incorporate specific programming, motion control and compensation functions for complex machining tasks in addition to high-performance hardware. These function alities simplify work for the user and guide him effectively through the entire machining process. It is also important to match and optimizemotion control to the requirements of the particular machining task. Rigidity and accuracy of the machine have a considerable influence on precision and surface quality, and it is also important to improve these with special control and drive functions.

Requirements at a Glance
5-axis milling

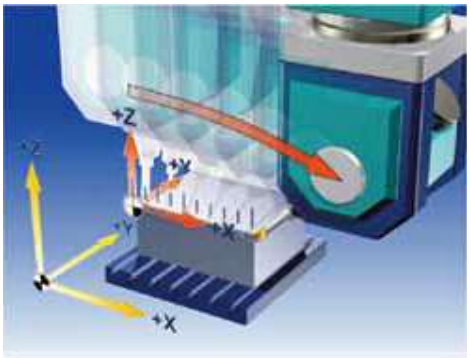
- **5-axis functions** for flexibility and optimum cutting conditions
- **User-friendly programming functions** for simple machine handling
- **Intelligent motion control** for maximum speed, dimensional accuracy and surface quality
- **Compensation functions** to counter interference and machine inaccuracies

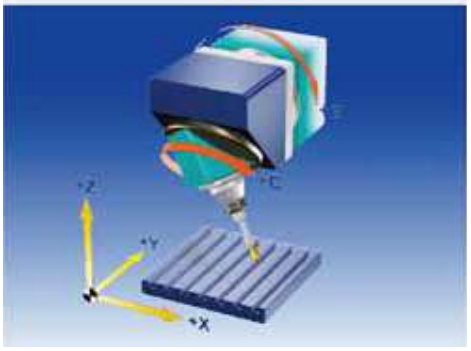
5-axis Functions

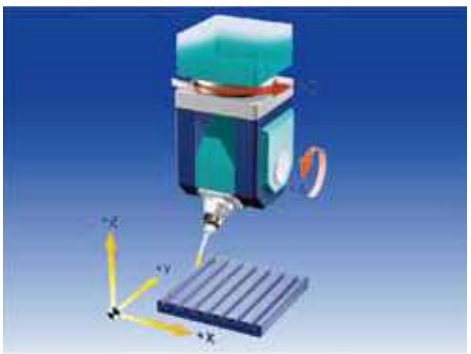
5-axis functions for flexibility and optimum cutting conditions

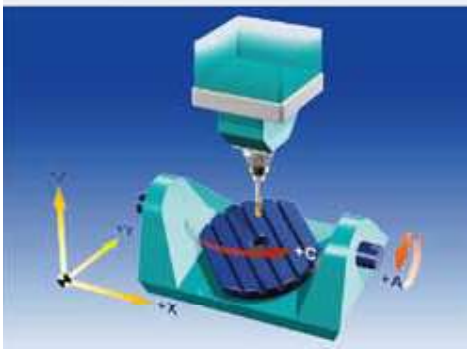
The fact that the cinematic characteristics of 5-axis machines can be very different in itself poses a challenge for NC control.Whereas in some cases a swiveling/rotary table is realized with two axes of rotation, in another case the machining table does not move. This means that it is always possible to program in workpiece coordinates rather than in machine axes, so that even highly complex workpieces can be manufactured on machines with different cinematic characteristics without a specific postprocessor run. All necessary compensation motions are calculated internally by the control unit and this ensures that the machine can be run at the programmed feed speed, with the machine mechanism acting as the sole restricting factor.

What is more, only with the aid of these 5-axis transformations can tools be controlled manually after a tool break or fault and be safely withdrawn.







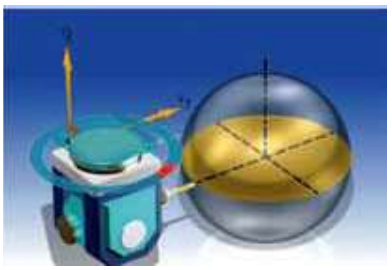


User-friendly programming Functions

User-friendly programming functions for simple machine handling

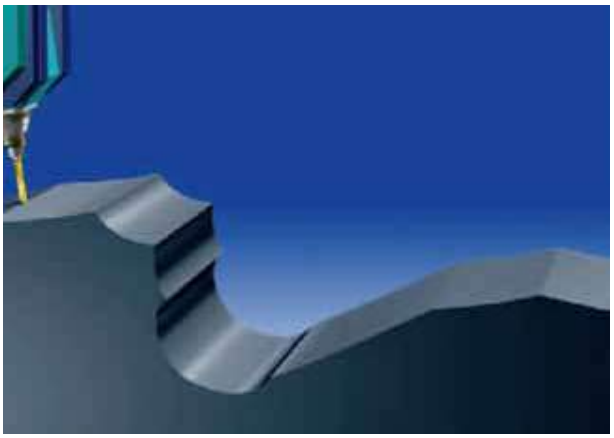
Great circle interpolation (ORIVECT)

An orientation interpolation has been developed for milling thin-walled pockets, which guide a cylindrical milling cutter with defined inclination exactly against the pocket walls. Instead of moving the round axes individually synchronously to the path, a tool vector is interpolated which moves exactly in the plane defined by the wall. This avoids the usual conical contouring errors associated with the con ventional method of peripheral milling. This means it is also possible to program longer linear sets without infringing the contour.



Path smoothing

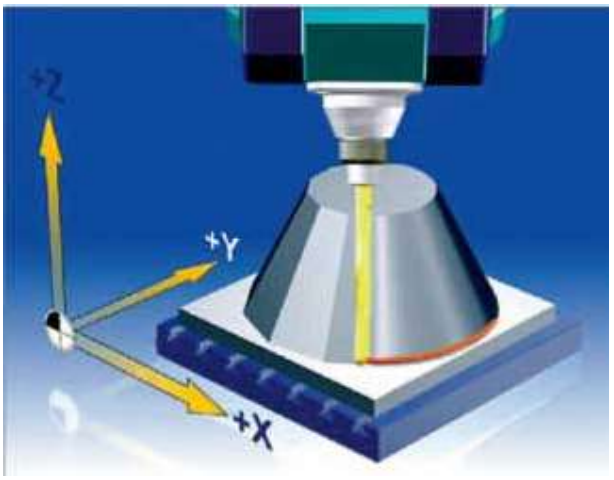
Since the tool vector is guided along even surfaces, edges occur at set transitions with peripheral milling. If they are unde sirable, they can be avoided by the path smoothing function so that a smooth orientation curve is achieved.



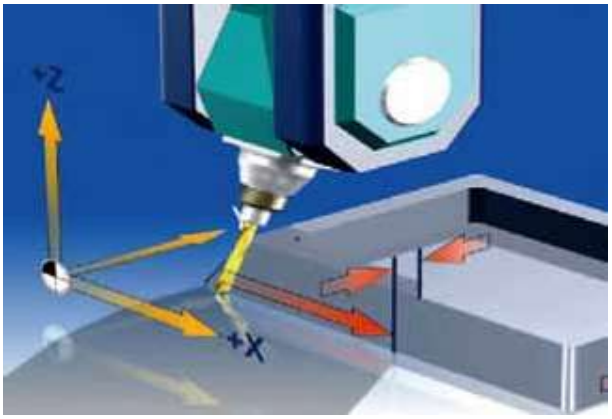
Application 5-axis Milling

Integrated 5-axis spline compressor

Residual irregularities in the surface finish resulting from the point-to-point program ming in the CAM system can be smoothed out easily with the aid of the integrated spline compressor function in the control unit. This offers the option of trans forming linear sets into B-spline sets or polynomials. The smoothing process also incorporates the programmed orientation vectors of the particular tool setting which results in considerably more even speed profiles related to the tool center point (TCP) so that substantially higher traversing speeds are achieved with excellent surface qualities.



3D tool radius correction



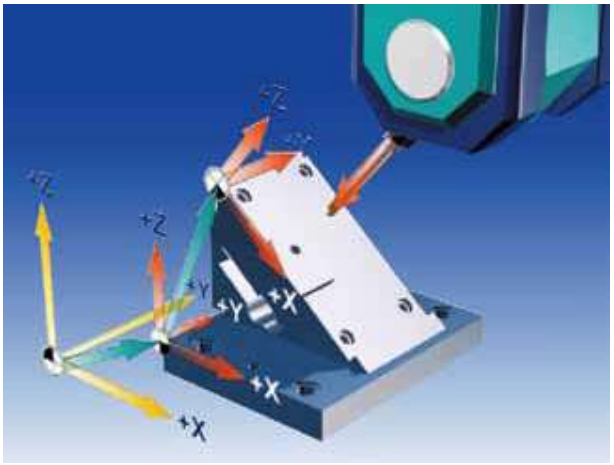
The ability to calculate tool wear online in the control unit enables resharpened tools to be used without an additional postprocessor run. Whereas the control unit does not need any additional information about the surface to be machined for making corrections during peripheral milling, with face milling the normal line to the surface is needed as well as the TCP and tool direction vector.

User-friendly Programming Functions

User-friendly programming functions for simple machine handling

Frame concept

The Frame concept allows shifting, rotating, scaling and mirroring of coordinate systems in Cartesian space. In conjunction with swiveling tools, this also makes the programming of complex workpieces considerably more flexible.

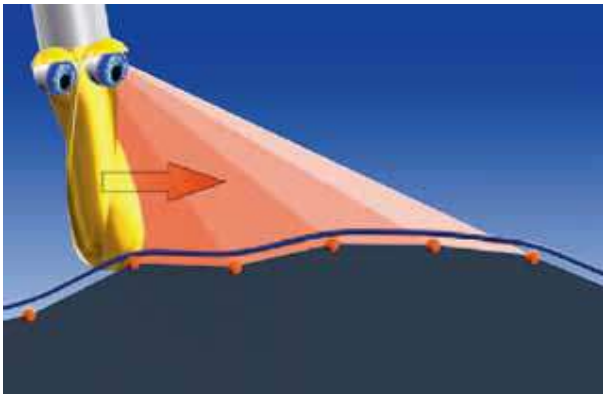


Intelligent Motion Control

Intelligent motion control for maximum speed, dimensional accuracy and surface quality

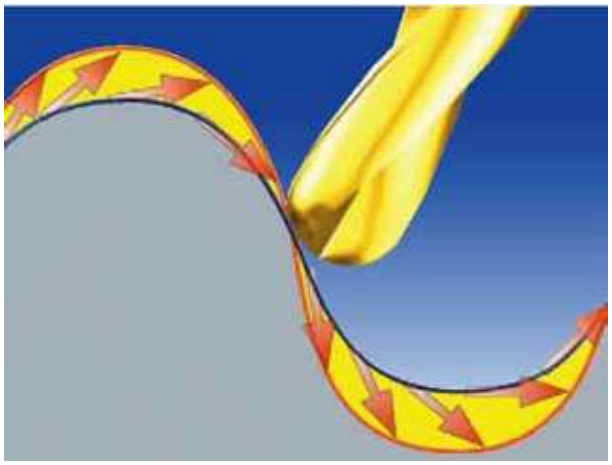
Look ahead

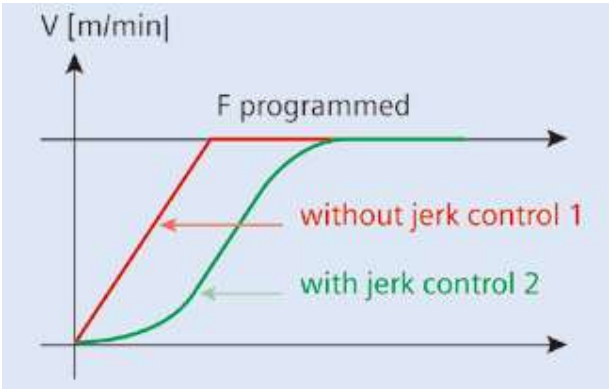
This function “sees” a settable number of traversing sets in advance and calculates a speed profile for all the sets. Smooth, tangen tial transitions between sets are pro-cessed without loss of speed beyond the limits of the set.



Feed forward and jerk limitation

A contouring error results in falsification of the contour. Due to the inertia of the machine the tool leaves the nominal contour resulting in a contour error, the speed-dependent contouring error when tracking a path is reduced to almost zero.If the machine is operated with jerk limitation, the acceleration characteristic does not change abruptly but increases in linear fashion. In this way, the machine is not excited to oscillate, and wear and tear on the mechanism is reduced.





Load-dependent acceleration

In the case of cinematics with traversing machine tables, the control unit can automatically calculate optimum settings for acceleration and jerk depending on the actual weight of the workpiece being moved. As a result, machines can always be operated at their upper limit and maximum productivity is achieved.

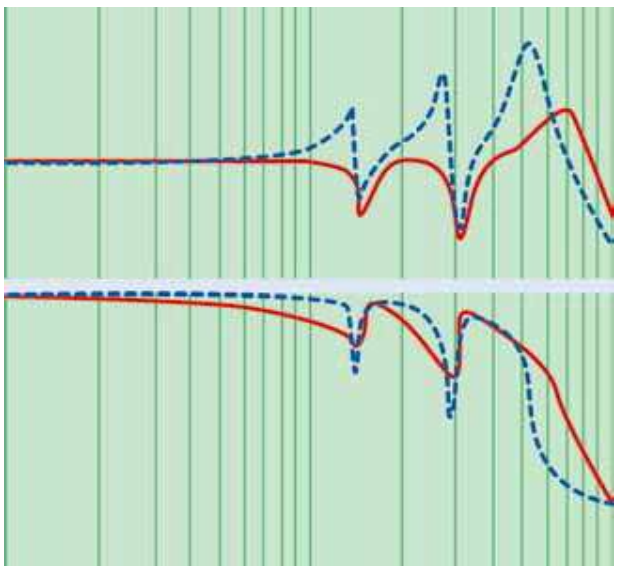
Compensation Functions

Compensation functions to counter interference and machine inaccuracies

Active damping of vibrations to prevent resonating (APC)

Surface quality suffers whenever an axis oscillates due to process forces or violation ofa rule. In the case of larger machines, the influence of the mechanics cannot be completely eliminated. Corrective action can be achieved through active vibration damping where the appropriate prerequisites exist, automatic control engineering can dampen the vibrations emanating from the mechanical system. This is possible through feedback or connection of signals from the direct measurement system of an axis onto the target value for speed. Aside from the motor sensor system, the function requires a second sensor system located directly on the traversing table. Due to higher values for return and controller amplitude (Kv factor) it is also possible to set even larger machines significantly more dynamically.

This not only improves the surface quality, but also notably reduces machining times. Furthermore, with the function “Auto Servo Tuning,“ it is possible to determine the moments of inertia of workpieces and also the elasticities of the clamping devices. As a function of these parameters, the control circuits and the drive train can be optimized to a higher dynamic.



Study on the Inspection of Scraping Guide Way

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Abstract—Based on image morphology technology and using an IEEE 1394 digital camera as an image capturing tool, this study was able to determine the number of actual contacts of each area on box guide ways and the distribution uniformity of each area of the machine. Using the work of an experienced scraping technician as an example, there should be 16~24 points on the bearing surface per square inch, which is considered to be an acceptable level of tolerance. The performance of the tolerance of box guide ways can be determined to ensure the precision of the machine. Evenly distributed lubrication on the surface of box guide ways can prolong the lifetime of a machine. This study eliminates the disadvantages of naked-eye inspections performed by quality control inspectors. After practical testing, the contact points on the box guide ways can be verified. This will greatly reduce machine production costs, which are generated by a lack of personal inspection and the need to repeat a scraping job. A computerized inspection record will also be very useful for after-sale service.

Keyword: Image Processing, Scraping Guide Way, Inspection of Scraping

I. Introduction

The mass production of linear guide ways effectively improved the production speed of traditional machines and the rapid speed of linear motion. Many machine guide ways perform with high precision and low anti-resistance, and although high rigidity is still required, such as for a bridge-type grinding machine or a gantry milling machine, these type of machines can still be used by box guide ways. The main reason is that heavy duty machines are always provided with extremely large axes force and radius force, but a linear guide way is unable to achieve the necessary force, and its bearing capacity remains insufficient for a large machine. Therefore, the box guide way is still the most often used mechanical structure for heavy duty machines.

However, the number of contacting points and the surface finish acceptance of a box guide way still depends on the subjective judgment of a scraping technician to determine if the box guide ways are suitable as shown in Fig. 1. Examining the contact point with the naked eye is an unreliable method. Determining whether the contact points are evenly distributed and if the area of each contact point is within an allowable range that meets the requirements for the uniform forces exerted on the guide way surface is a critical factor in determining the precision and the lifetime of a machine. Unfortunately, personal inspections are time-consuming, and, in general, many experienced technicians are gradually retiring, and few younger people are willing to learn the process of inspecting machine scraping. Although motorized scraping machines exist, they are normally used in the last step of machining which is for fine scraping only, and it is not possible for the guide way toensure the precision of the machine. There has been research into these theories of image morphology technology in which CAD/CAPP/CAM software technologies have been introduced. Practically, considering the assembly after each component is completed, this study is advantageous for meeting the precision requirement and is also convenient for determining the nature of the scraping, which thereby improves the quality of the machine. However, the durability of a machine cannot be guaranteed because the research [1-4] has neglected to examine the importance of uniform lubrication and the contact points of the box ways surface. The Profile Matching Method is adopted to measure the straightness of the guide way of a machine. Although this method is useful for the inspection of new machines and for tolerance compliance [5-6], it is unable to assure the precision of a machine in the long term. Fundamentally, the basis of the method is to precisely inspect the uniformity of the machine and control the area of each contact point of the bearing surface. This is the most important issue for ensuring the quality of a machine.

The theoretical basis of this research is image morphology that is used to design portable inspection equipment, which is applicable for different working distances and applications. The design structure is shown in Fig. 2. This Scraping Guide Ways Inspection device can effectively and quickly verify the uniformity and the area of each scraping point on the bearing surface of a machine and ensure that the quantity of contacting points meets the requirement of 16-24 points for each square inch. This helps to control the tolerance of machine.

Image morphology is applied to extract the geometric features of binary images, such as the noise treatment of an image or the intensification of the structure of an object. The basic image morphology includes four functions as follows: (1) Dilation is performed by an algorithm to increase or thicken objects in a binary image. The manner and degree of escalation are controlled by the shape of the structuring element. Usually it is used to fill small holes in objects or to thicken lines. (2) Erosion is performed by an algorithm that is used to shrink or thin objects in a binary image. The manner and degree of shrinkage are also controlled by a physical structuring element, which is usually used to clear noise or to thin lines. (3) Morphological opening is defined as using the erosion algorithm on an

image. The expansion algorithm is then applied, usually used to eliminate the small details in the image and maintain most of the shapes of the objects. (4) Morphological closing is defined as using the expansion algorithm on an image. Then, the erosion algorithm is used to connect adjacent objects, fill seams, and smooth the edges of objects [7-12].

The data in an image that are used to segment different objects are applied to the main function of image segmentation. There are four different common technologies that are used segment of a grey-scale image. They are described as follows: (1) Threshold-based segmentation [13-14] uses a grey-scale statistical bar chart to determine the suitable threshold values used to segment objects from the background. (2) Boundary-based segmentation [10] uses the obvious variations of brightness between the object and the background to determine the edges of the objects. (3) Region-based segmentation [15] is used to tag similar brightness in an adjacent image for segmentation. (4) Hybrid segmentation is used to combine all of the above three methods for segmentation to achieve better segmentation. Among these, watershed segmentation [16] is one of the most common type been used.

Following the ASTM E702-85(2010) inspection standard for the machine manufacturing industry, the contact surface of the scraping is required to be approximately 16-24 points that are evenly distributed in an area of one square inch. The inspection method is used to apply reagents on the surface of a guide way and move the scraped sliding elements back and forth on a surface that is being scraped. Therefore, the surface of the sliding element has obvious reagents, as shown in Fig. 1, that assist the quality controller in identifying the number of contact points and ensuring that they meet the requirements. Unlike the method in which the reagent is determined by the naked eye, this method adopts a CCD camera that is used to identify the sliding element, which is not used with a reagent. Though the calibration of image, it can convert the image coordinate system to the world coordinate system to further recognize the number, area, and uniformity of the contact points with each square inch, which can then be analysed by a computer to determine the quality.

Fig. 1 Reagents on the Surface of a Guide Way

II. System Structure

The image analyst system is a PC-based structure consisting of an IEEE 1394 digital camera, a video extraction card, and a light regulator. The processes and analyses of the image are performed by LabVIEW and MATLAB from the National Instrument. The transmission speed of the IEEE 1394 digital camera is fast and precise, the maximum shooting speed is up to 400Mbit/s, and the parameters of camera can be adjusted by software, such as shutter speed, white balance, and gain values. Fig. 2 shows the mechanism drawings of the scraping guide ways inspection device. Fig. 2(a) and 2(b) show the top view and the side view of the scraping guide ways inspection device, respectively. "B" is light regulator as shown in Fig. 2(a), which is used to adjust the reflective brightness on the scraped surface; it is used to stabilize the algorithm for image processing. "C" is a hand wheel, which is used to drive the gear rotation on the rack so that the entire inspection platform can be moved upward and downward with a stroke distance of 280 mm. When combined with a lens ranging from 8 mm-48 mm, this device is able to determine the ranged view area from the farthest 500 cm2 to the nearest 230 cm2. The turret design is able to adjust the angle of the camera and the light regulator in a range of ±65°. The 60°V shape guide way slope can also be inspected. The linear guide way can be used to control the movement of the inspection platform, in both directions with a movable stroke for 200 mm. "A" is the front edge in Fig. 2(b), which meets the requirement that the inspection platform can move easily. The total movement is 325 mm. This range meets most inspection requirements for a guide way surface.

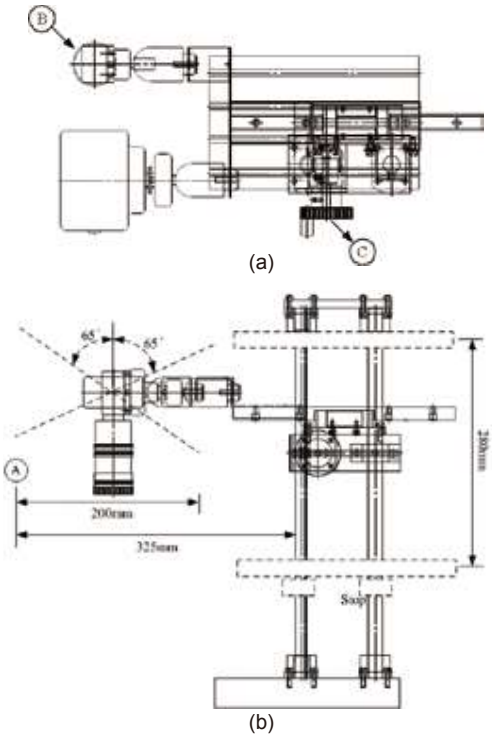


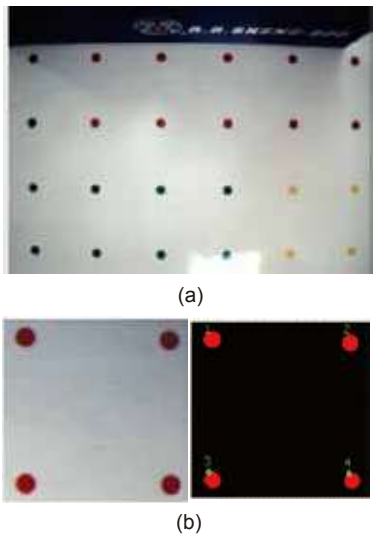
Fig. 2 The Prototype Scraping Inspection Machine .
(a) Top view (b) Side view

III. Image Calibration

In the image plane, pixels are the unit used to represent the image element. To realize the size in the image plane, the system must calibrate the images to convert the image coordinate system to the world coordinate system. In this experiment, a calibration plate is distributed with points in various colours. The interval of each point is within one inch. Therefore, every four points circled one square inch. Fig. 3(a) shows the image calibration plate. Fig. 3(b) (left) shows the range of the Region of Interest (ROI) in Fig. 3(a). Fig. 3(b) (left) is converted to the HSI colour space. This can easily extract red, which is more saturated. The HSI colour space illustration is shown in Fig. 4. The HSI colour space represents colours using hue, saturation, and intensity. Hue indicates the wavelength of the light reflected from an object. Different wavelengths represent different colours. In the HSI colour space, Hue indicates the object colour, e.g., H=0° represents red, H=120° represents green, and H=240° represents blue. Saturation indicates the sharpness of the colour. The centre point is located when S=0. When the S value is closer to the centre, the colour is lighter, such as light blue, light red, light green, and so on. When the S value is closer to the edge, the colour is darker, such as dark blue, dark red, dark green, and so on. Intensity indicates the relative shading in the grey-scale image. I=0 represents dark (black), and I=1 represents as bright (white). Therefore, the red points can be extracted as they have higher saturated values. This study used a range of saturation within 200~255. The data of the red points are shown in Table 1. The mass centre and the area of Red Point 1 are located at (17.2, 16.6) and 154 pixels, those of Red Point 2 are located at (135, 17.2) and 149 pixels, those of Red Point 3 are located at (17.4, 135.5) and 152 pixels, and those of Red Point 4 are located at (136.7, 136.1) and 150 pixels, respectively. As shown in Table 1, even though the sizes of the four points are the same, the results obtained in the image plane are slightly different. This is due to distortion that is caused by the camera itself and the difference in saturation, which is due to uneven lighting. The maximum difference of a red point is 5 pixels, which is negligible because this has almost no influence. The distances between red points can be obtained by Equation (1). X=118.5, Y=118.9, and each point is the length of the image plane for 1 inch. Thus, the ROI used to verify the scarping image is an area of 119 pixels long and 119 pixels wide.

$$X = \frac{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} + \sqrt{(x_4 - x_3)^2 + (y_4 - y_3)^2}}{2}$$

$$Y = \frac{\sqrt{(x_3 - x_1)^2 + (y_3 - y_1)^2} + \sqrt{(x_4 - x_2)^2 + (y_4 - y_2)^2}}{2}$$



(a)

(b)

Fig. 3 Image Calibration Plate
(a) Image calibration plate (b) the range of ROI

Table 1 image data of calibration plate Unit: pixel

	1	2	3	4
Center of Mass X	17.2	135	17.4	136.7
Center of Mass Y	16.6	17.2	135.5	136.1
Area	154	149	152	150

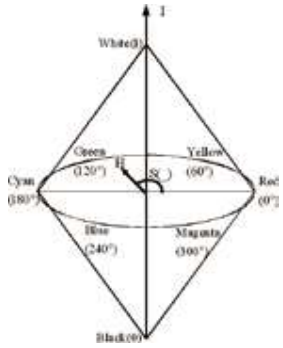


Fig. 4 HSI colour space

IV. Image Analysis

Through image calibration, a size of one square inch can be obtained in the image plane, which is assigned as the ROI of image, and the image in the ROI is calculated to determine if it complies with the scraping requirements. Several issues are encountered when using these images, including whether it is problematic to have identical sizes at the crest due to manual scraping, and the fact that, in the area of each square inch, there are many incomplete points around the edges. To resolve these issues, a contact of 16 points in each square inch is set as a standard. Therefore, 1/16 of 1 square inch is used as a mask for scanning the images. In addition, a convolution algorithm is used with the images. The size of the scraping crest should be larger than 1/16 and smaller than 1/4 of the mask as shown in Fig. 5. If there is no crest found in the convolution algorithm, it is disqualified. The disqualified area is then marked for reference.

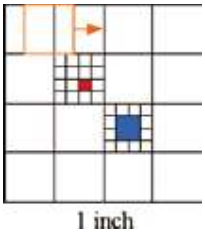
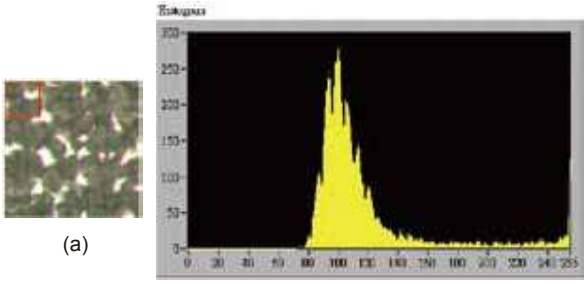


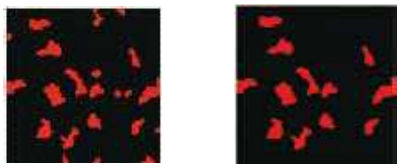
Fig. 5 Scanning images method

This study uses threshold segmentation to segment the disqualified scraping area. Threshold segmentation is a method used to determine suitable critical values using histograms. Fig. 6(a) shows the original image of the scraping. The red frame is a scanning area of 1/16 square inches. The scanning procedure began from left to right and from top to bottom. Fig. 6(b) shows the histogram of the scraping image. Brightness values of 100 were the maximum quantity in the image used to determine the reflective surface in Fig. 6(a), which indicates that the brightness value is slightly too high. Therefore, the threshold was set between 100 and 255. The binary image was obtained as shown in Fig. 7(a). Fig. 7(a) shows the highest number of crests that require scraping that can be segmented by threshold segmentation. However, there was still some slight noise that must be filtered out. The effective crest size defined above in the 119×119 images in this experiment is defined in a range between 55 and 221. Therefore, a crest that is not within this range is deemed to be noise and filtered out. Fig. 7(b) shows the result when the noise is cleared.



(a) (b)

Fig. 6 Image processing by histogram
(a) Original image of scraping (b) Histogram of scraping image



(a) (b)

Fig. 7 Threshold segmentation result
(a) Threshold segmentation result
(b) Noises removed result

The crests in image scraping can be segmented using the image processing procedures mentioned above. Next, the entire image is verified with an area of 1/16 square inches, which is set as described above. The method then uses a convolution algorithm on the image in this area. The searched areas that are disqualified are marked as 1. An image of M×N is set f, and the mask T is the value of the matrix m×m = 1. The calculation of the equation convolution is given in Equation (2). Fig. 8(a) shows the result of Equation (2). The image f' is a binary image. The position marked with "1" represents the location that is determined by mask "T" to be disqualified. The image f' is the convolution through morphology with another mask "G". All of the disqualified areas can be extracted by Equation (3). Fig. 8(b) shows the result of the convolution. It clearly shows where the disqualified areas are located.

$$f'(x,y) = T * f(x,y)$$
$$= \sum_{i=0}^{m-1}\sum_{j=0}^{m-1} T(i,j) f\left(x+i-\frac{m-1}{2}, y+j-\frac{m-1}{2}\right)$$

(x=0,1,…,M-1;y=0,1,…,N-1;i=0,1,…,m-1;j=0,1,…,m-1)

$$\begin{cases} T * f(x,y) \le 0, & f'(x,y) = 1 \\ T * f(x,y) > 0, & f'(x,y) = 0 \end{cases}$$

$$f''(x,y) = G * f'(x,y)$$
$$= \sum_{i=0}^{n-1}\sum_{j=0}^{n-1} G(i,j) f\left(x+i-\frac{n-1}{2}, y+j-\frac{n-1}{2}\right)$$

(x=0,1,…,M-1;y=0,1,…,N-1;i=0,1,…,n-1;j=0,1,…,n-1)

$$\begin{cases} G * f'(x,y) \ge 1, & f''(x,y) = 1 \\ G * f'(x,y) < 1, & f''(x,y) = 0 \end{cases}$$

(a) (b)

Fig. 8 convolution result

V. Experiment

Fig. 9 shows a prototype of a scraping guide ways inspection device. The design of the stand can be varied along with the range of movement where the inspected items are stored. Different angles can also be applied. Tripods with various lengths can be used. The fixture of camera can be adjusted upward or downward with a travel distance of 280 mm, which was used to obtain the best focus range. This fixture can be also moved forward or backward in a range of 200 mm, which allows for awide range of inspection.

Fig. 9 Prototype of a scraping guide ways inspection device

Fig. 10 shows the result of the processed scraping image. The details are described as follows:

(1) Fig. 10(a1) shows the first original scraping image. Using the image processing method described above shows that the brightness was greater than 100 with threshold segmentation. Fig. 10(a2) shows that 21 scraping points were found. However, the sizes of the points were different. All of the points were either too large or too small, which was deemed to be an ineffective crest. Thus, Fig. 10 (a3) was obtained using the sieve of the effective crests. The effective crests were composed of 10 points. The image was formatted with a convolution algorithm with a 1/16 square inches mask. Disqualified locations were marked as 1. The red area, as shown in Fig. 10(a4), consisted of all of the marked locations. The image shown in Fig. 10(a4) was formatted with the convolution algorithm. The purpose was to spread the points marked as 1 to the areas as shown in Fig. 9(a5). Then, the disqualified areas were marked in Fig. 10(a3). Inspectors can determine the disqualified areas as shown in Fig. 10 (a6). The results showed that there were there 10 points of scraping contact, which does not meet the requirement. Based on the uniformity inspection, four areas were disqualified.

(2) Fig.10(b1) shows the second original scraping image. Using threshold segmentation, 19 scraping points were found. The result is shown in Fig. 10(b2). Through the procedure, the sieve of effective crest was obtained as shown in Fig. 10(b3). The effective crests had 13 points. By using the convolution algorithm two times, the disqualified locations were marked, and the points were spread to

different areas, which are shown in Fig. 10(b4) and Fig. 9(b5). Then, the disqualified areas were marked in Fig. 10(b3). The inspectors can then determine which areas are disqualified. The result is shown in Fig. 10(b6). It was confirmed that the number of scraping contact points was only 13, which does not meet the requirement. The uniformity inspection clearly showed that a large area was disqualified.

(3). Fig. 10(c1) shows the third original scraping image. Through threshold segmentation, 24 scraping points were found, among which 12 points were effective crests. The results as shown in Fig. 10(c6), the number of scraping contact point was only 12, which did not meet the requirement. The uniformity inspection clearly showed that 3 large areas were disqualified.

(4). Fig. 10(d1) shows the fourth original scraping image. Through threshold segmentation, 19 scraping points were found, among which there were 14 points that were effective crests. From Fig. 10(d6), the number of scraping contact points was 14, which did not meet the requirement. The uniformity inspection clearly showed that one area was disqualified.

(5). Fig. 10(e1) shows the fifth original scraping image. Through threshold segmentation, 16 scraping points were found, among which there were 10 points that were effective crests. Fig. 10(e6) shows that the number of scraping contact points was 10, which did not meet the requirement. The uniformity inspection clearly showed that 3 areas were disqualified.

From the results as mentioned above, it was determined that all of the disqualified numbers of bearing points and their areas could be clearly found. This also verified that the methods for image processing adopted in this research worked very well. Fig. 11 shows the human-machine interface. The image on the left is the original image captured by the camera. The red frame in the photo is a scanning area of 1/16 square inches. The image on the right was obtained through the image processing methods described above. When the area of a disqualified block is 0, and the number of effective contact points were between 16~24, it is determined as qualified, and the OK indicator lights up. However, if one of the conditions is not met, it is determined to be disqualified, and an NG indicator lights up. Using the coordinates and the area, the locations and the sizes of all of the points can be found. The smallest was at point (11.68, 7.24) with area of 2.56 mm2, and the largest was at point (17.84, 7.87) with area of 6.14 mm2. This result is shown in Fig. 11, which shows the analysis result of Fig.10(e6). This research used the inspection item as an example to input data into the LabView system for analysis. The analysis report shows that the area of the disqualified block was 297.392 mm2, and the effective contact points were only 10, which did not meet the standard. Therefore, the result was determined to be NG. Fig. 11 shows that X and Y mark the coordinate location of the inspected points. The area of the inspected point was calculated by a computer. In addition, the qualification can be determined by verifying whether this area is larger than the set area.

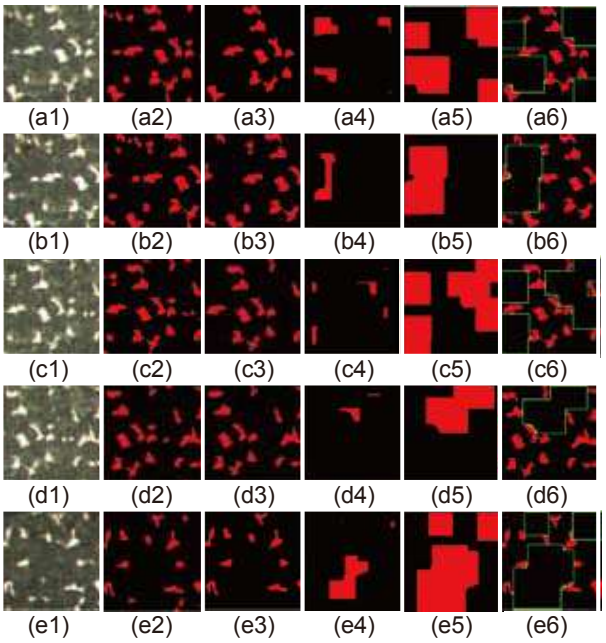


Fig. 10 result of processing scraping image

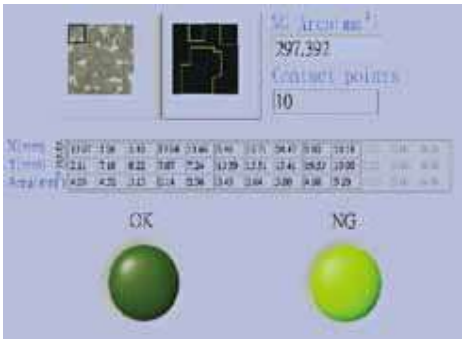


Fig. 11 LabView system analysis report

VI. Conclusion

The scraping guide ways inspection device can accurately inspect the contact points of the guide way of a machine. The following conclusions can be made from this research:

(1) The study was able to accurately inspect the contact points of a sliding surface on guide ways with optical methods to ensure the precision and quantity of the contact points of the guide way.

(2) Digitized inspection data were obtained. In addition to the number of contact points and the uniformity, the area of each point can be calculated to eliminate possible errors caused by determinations with the naked eye.

(3) The mistakes caused by human inspection can be avoided, and time wasting can be avoided during the assembly of a machine, which can be dismantled to improve the production margin.

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