



Selecting a Dental Machining Center

CONSTRUCTION CHARACTERISTICS OF AN EFFECTIVE DENTAL MACHINING CENTER

Of the many components that make up the Digital Dental Manufacturing Solution, the milling machine stands as the heart of the system. While many dental mills are capable of manufacturing soft materials, few DMC's (Dental Machining Centers) can effectively, reliably and profitably provide the ability to utilize the entire range of materials in use today or that will be most certainly be available in the future.

The key is finding a small footprint milling machine that offers all the best features and benefits of large industrial high speed CNC machine tools that is reliable, easy to operate and requires minimum maintenance. Such a machine would require adherence to strict design standards, use of high precision components, flawless assembly and the rigidity to insure the surface finish of the end product produced is of the highest quality.

WHAT FEATURES MAKE UP A GREAT DENTAL MACHINING CENTER?

A general answer would be that which provides the ability of the DMC to quickly and accurately produce a finished product while maintaining the geometric integrity of the cutting tool while engaged in the material being machined.

While frequently overlooked, the internal makeup of the machine does have a significant impact on the quality of the final products and overall reliability of the machine. A great method of visualizing this would be to imagine having one wheel on your automobile out of balance. A balanced wheel offers a smooth ride while an unbalanced wheel produces vibration, increases wear on tires and drivetrain components and introduces all manner of handling problems.

Just as a balanced drive system greatly improves your automobiles ride comfort, reliability and life expectancy; a well-balanced, smooth running, vibration free Dental Machining Center will greatly increase the quality and accuracy of any dental restoration while increasing cutting tool life and requiring much less error inducing, profit robbing post-machining processing.



It is important to remember: **Heat and vibration are the enemy** and must be eliminated in every way possible. Let me repeat: **Heat and vibration are the enemy** and is dependent on several factors, Including:

- Quality and Geometry of Available Tooling.
- Spindle Construction, Accuracy and Repeatability.
- Machine Axes Drive System.
- Ability to Properly and Securely Hold the Material Being Machined.
- Capability of the Internal Machine Structure to Dissipate Heat, Dampen Vibration and Absorb Forces from the Machining Process.

Today there is a wide variety of CNC dental machining centers available to suite a variety of needs and choosing the right one for you can seem to be a daunting task.

Knowing the construction characteristics of these machine tools and how they affect operation, reliability, quality of output and cost of ownership can aid greatly in making an educated decision when choosing the most effective one for a given application.

Quite simply the “perfect” dental machining center (DMC) is one that best matches your needs. Knowing what you need is the key.

It is very difficult to determine whether and given DMC is the right one for you just by looking at it--or even by studying its features and specifications -until you fully understand your own needs, long term goals and objectives.

Major factors to consider are the materials to be machined, production volumes, controls, quality, machining operations, service and maintenance. To get the most from your machine tool investment, you have to match your needs to the DMC's characteristics, features, and options. The best approach is to start with a needs and usage analysis, this will help in deciding what is truly a necessity and what is really not so important.

The objective of every machining operation is to remove material within tolerances as quickly as possible. The issue for every lab or milling center is to define the amount of material, how quickly, what tolerances are required and how much post-machining hand work is required to produce a final sellable product.

POWER, SPEED & ACCURACY

There are a lot of interrelated factors that affect a DMC's power, speed and accuracy. The three basics include the spindle drive system, machine operating system (CNC control), and the axis drive system.

The spindle drive system provides power to the cutting tool to remove material. The machine control or "machine operating system" is the brain of the VMC and coordinates machine motion. The axis drive system determines how smooth the motion of the DMC is and how that translate into parts that are consistently accurate with the required surface finish quality.

The quality of the axis drive system is a function of the construction of the frame and the machine axes way system. This aspect of the machine determines rigidity, vibration damping capacity, and resistance to side thrust.

It's the balance between these three critical areas (power, speed, accuracy) that must be evaluate against your needs to get the best buy for your money.

BASIC REQUIREMENTS

Basic requirements for your DMC, such as spindle rpm, low speed torque, and high speed horsepower are established by the materials that will be machined. For example, soft materials require higher speeds for finishing, while hard materials require low-speed torque, as well as rigidity to reduce the effects of side thrust.

Following is a list of commonly used materials matched to the corresponding machine requirements and the feature or features that meet that need.

MATERIAL	REQUIREMENTS	NECESSARY FEATURES
Zirconia	High Speed Accuracy Surface Finish	<div style="display: flex; flex-wrap: wrap; gap: 10px;"> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Thermal Stability</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Dust Restraint System (Dry Machining)</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Program/Block Execution</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Spindle Drive Motor</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Support for Acute Change in Motion Direction</div> </div>
Cobalt-Chrome	High Torque At Low RPM	<div style="display: flex; flex-wrap: wrap; gap: 10px;"> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Vibration Dampening</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Rigidity</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Spindle Torque</div> </div>
Stainless Steel and Steel	High Torque At Low RPM	<div style="display: flex; flex-wrap: wrap; gap: 10px;"> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Vibration Dampening</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Rigidity</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Spindle Torque</div> </div>
Titanium	High Torque At Low RPM	<div style="display: flex; flex-wrap: wrap; gap: 10px;"> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Vibration Dampening</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Rigidity</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">Spindle Torque</div> <div style="border: 1px solid black; padding: 5px; margin: 2px;">High Axis Thrust</div> </div>

PRODUCTION VOLUME

Of course throughput is important. But throughput of low or moderate volume “short-run” applications requires a DMC with a different feature set than that which is required for long production runs.

If you're machining in low to moderate volumes, then anything that makes setups faster and easier is going to be important (i.e. program editing, access to the control from the work envelope, table height, thermal stability, etc.). If the DMC is utilized for high-volume or dedicated production runs, then automatic loading and chip removal are going to be important.

QUALITY

Quality is a function of the control, encoder, ways system, construction, and rigidity. There are several different types of encoders available, including rotary encoders, glass scales and laser scales. They provide progressively higher accuracy at higher speeds.

Another issue is the ways system, which affects rigidity, vibration damping, and the ability to withstand side thrust during heavy machining operations.

REQUIREMENTS	NECESSARY FEATURES
Accuracy	<ul style="list-style-type: none">High-speed Machine ControlEncodersRigidityWaysConstruction
Repeatability	<ul style="list-style-type: none">Thermal StabilityEncodersRigidityWays SystemConstruction
Surface Finish	<ul style="list-style-type: none">High-speed Machine ControlHigh RPMWays SystemVibration DampeningSpindle Concentricity (Balance)

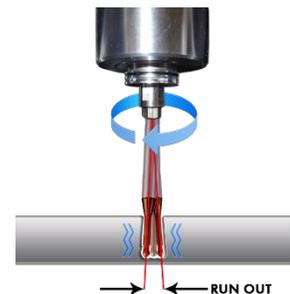
MACHINING OPERATIONS

The DMC features that are needed to machine dental prosthesis with 3D contours include:

- Smooth Contours
- Accuracy
- Smooth Surface Finish
- High RPM
- Program Execution Speed
- Rigidity
- Spindle Concentricity
- Ramp-Up/Ramp-Down Time For Angle Changes

SPINDLE DRIVE SYSTEM

Generally, the spindle is considered the heart of the DMC. The spindle holds the tool and performs the material-cutting operations. The spindle must have low, consistent runout, stiffness, rolling torque, low heat generation, and thermal stability. Most machine spindles are better at certain applications than others. For example, a spindle that machines zirconia at high speeds may not have the same metal-cutting capability at low speeds as would a spindle DESIGNED for low speed, high torque cutting operations.



Spindles come in a variety of speed, torque, and horsepower ratings. Since the workpiece material has a bearing on speeds, torque and horsepower it is important to make sure the spindle of the DMC has the required speed and power to machine the variety of materials required. Key to qualifying a DMC in this respect is the understanding of a spindle's horsepower (typically rated in terms of watts or kilowatts) and torque (typically rated in terms of Ncm). This gets further complicated because not all machine manufacturers document their machines spindle in the same ratings classification.

Electric motors carry both continuous and short-term duty ratings. Machining forces, such as applying a cutting tool to a workpiece, put a load on the motor and the greater this cutting force, the more motor output is required to maintain RPM. As the motor output increases, so does the motor temperature, Machining processes have to be designed so required power/torque at a speed is less than the available power/torque. When the process exceeds the available power and torque, it overheats the motor - eventually burning it out. Obviously not a good thing as it results in a significant expense and loss of production.

Based on different duty cycle ratings, rated power and torques have different values. It is important to distinguish the different ratings so the application is designed for a machine's capabilities. The International Electro-technical Commission--IEC--has released a duty cycle rating standard.

Every motor has a continuous-duty rating for power and torque--an S1 rating. S1 is based on reaching thermal equilibrium on a sufficiently long duration. Since most motors in machine tools--axes or spindle motors--are used in a non-continuous duty cycle, the power/torque capability is higher than the continuous duty cycle, since the motor heats up differently. A standard specification--IEC 34--describes the capability of a motor based on a set duty cycle.

The ratings are S1 through S9. The four ratings for machine tool spindles are S1, S3, S6, and peak load ratings:

- S1 -- Continuous duty rating: Constant load with duration long enough for motor to reach thermal equilibrium.
- S3 -- Intermittent periodic duty type without starting: A sequence of similar duty cycles at constant load separated by no-load--zero spindle speed--conditions.
- S6 -- Continuous operation--periodic duty type: A sequence of similar duty cycles at constant load separated by no-load--but continuously running--condition.
- S3 and S6 ratings are expressed as power available for a given percentage of load period in a given cycle duration. When no cycle time duration is specified, a 10-minute time applies as default.
- 15hp S3-30%, 60min -- S3 rating for the spindle is 15hp available when the spindle is under constant load for 18 minutes--30 percent of the 60-minute cycle.
- 10KW S6-60% -- S6 rating of the spindle is 10 kW when the spindle is used under a constant load for 6 minutes--60 percent of a 10-minute cycle.
- Peak load rating -- The instantaneous power available for a very short burst, such as entering a cut, or for accelerating the spindle to speed.

AC vs DC SPINDLE TORQUE COMPARISON

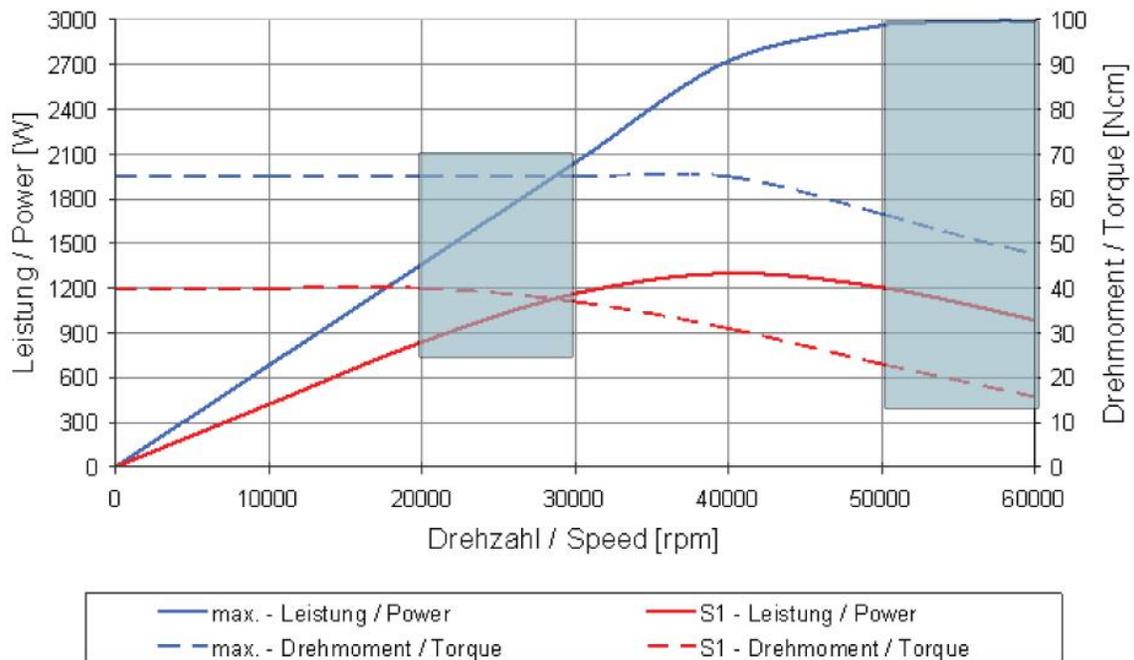
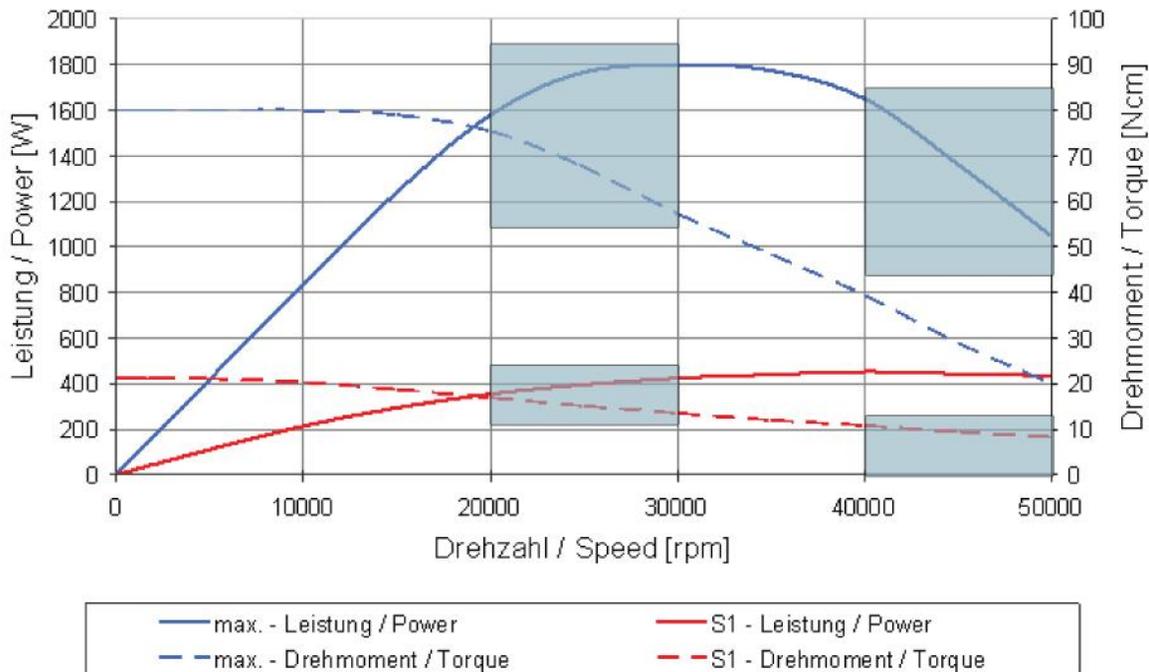


Figure 1: DC Spindle Figure 2: AC Spindle

A quick analysis of these graphs shows a typical Brand “X” AC Spindle (1.8kW), characteristically has high torque in the low rpm range. However this range is of no real concern or use in a DMC as we require the spindle to operate at high rpm.

The graphs also show the 3kW DC Spindle (currently used in the Versamill 5X-200 DMC), in the normal operating range for our applications, to be 2 to 3 times more powerful than the AC Spindle. For example:

At 0-45,000 rpm (which is actually quite sufficient) the DC spindle provides a constant torque of 65Ncm while the AC spindle provides significantly lower torque levels which decrease in value from approximately 58Ncm @ 30,000 rpm to only 29Ncm



@ 45,000 rpm (the most useful speed range) - at MAXIMUM rating. Further The AC spindle torque drops to a mere 9Ncm just over 40,000 rpm S1 – continuous duty rating.

To achieve shorter cycle times for dental restoration manufacturing high torque at high spindle speeds (S1 continuous duty ratings) is required, which most (if not all) AC spindles utilized in small footprint Dental CNC machines cannot provide at a level to meet the requirements of “hard milling” applications (i.e. titanium, chrome-cobalt, etc.). Of course specifications/curves change from manufacturer to manufacturer and model to model however this is what to characteristically expect.

Knowing machines' ratings offers two advantages. First, it allows a one-to-one comparison when considering a machine purchase. Second, it lets the design of the cutting process' required power/torque match the machine's rpm availability.

Many CNC machine motors simply do not perform well as heat increases, and may take a long time to cool down. Some can cool down only when at rest. These motors often run at temperatures above say 212° F when in the continuous-duty HP range. Other motors are designed to run at that maximum 212° F in the continuous-duty range, and begin to cool down as soon as the load reduces. This means that

even if a portion of a machining cycle requires maximum output, the motor will begin to cool as soon as the demand drops, even as the machine tool continues operating.

Temperature, of course, not only affects the life of the spindle motor, but other machine components such as ball screws and bearings. Additionally, thermal expansion can lead to out-of-tolerance parts with chipped margins and bad fits. So not only is it important for the motor to dissipate heat quickly, but also for the machine tool maker to build in methods for compensating for increased temperatures.

Horsepower and torque ratings alone don't provide enough information to make an informed decision about a motor's potential performance. Unfortunately, some of the off-the-shelf motors some DMC builders use have spindles that may appear to have adequate HP ratings, based upon power consumption rather than actual output, and may not meet other important criteria. For example, these generic motors may have higher operating temperatures that can impact the bearings, ball screws and other machine components. They may not cool down after short-term operation until they have stopped, idling the machine tool which means lost production time.

The spindle motor on a CNC machine tool should be designed and built to last the lifetime of the machine, not just for a stated number of hours. If the builder takes a holistic approach to the machine tool design, factors in all of the above considerations, and if routine maintenance is applied, barring any "crashes", the spindle motor will perform reliably for as long as the machine tool is functional.

A variety of spindle bearings are available, such as conventional roller, ball or hybrid bearings, ceramic bearings, hydrostatic, air, magnetic, and combinations. Each of the bearing systems has its own strengths and weaknesses. Roller bearings are stiff and durable but can generate heat, which detracts from performance. Typically, ball bearings generate less heat and run much faster than roller bearings, but are not as stiff. Hybrid bearings with ceramic balls and steel races can run faster than conventional ball bearings because they have less mass and more stiffness, but are more likely to fail in a crash (but less likely than all ceramic) because they are brittle.

CONSTRUCTION

The highest quality DMCs utilize castings because of their superior overall strength, vibration damping characteristics and low cost. Castings should have uniformly thick walls because variation in wall thickness can cause cooling and distortion problems. Thin sections can become brittle and cause distortion when under stress.

Some DMCs utilize weldments, which are usually made of steel. In small quantities, weldments cost less than castings and are stiffer and stronger when compared to castings of the same size and weight. However, generally speaking, weldments are and have less damping characteristics. So, they perform well at low speeds, but at high speeds weldments are more susceptible to vibration and chatter that can cause rough surface finishes, chipped margins and diminished cutting tool-life.



Figure 1: Aluminum frame while offering strength and rigidity provide less vibration dampening than cast machine frames.

Newer materials that are lighter, such as composites, aluminum and titanium, are also used in machine tool construction. These materials can provide significant advantages in the newer larger higher performance machines. For example, reduced mass makes acceleration and deceleration easier. The use of composite type materials has increased because of high strength-and-stiffness to weight ratios as well as thermal stability.

WAY SYSTEMS

The machine tool way system includes the load-bearing components that support the spindle and table, as well as guide their movement. Box ways and linear guides are the two primary types of way systems. Each system has its positive and negative characteristics. Unfortunately, one type of way system is not appropriate for all applications. So, when you're in the market for a machine tool, you have to match the way system to your specific application.

The vast majority of high-quality DMC's utilize linear guides which provides fast positioning and smooth motion with light-weight dental materials- at a comparatively low price point when compared to box ways.

Not all liner guide systems are created equal. It is important that a DMC's guide system be of adequate size to support short-travel, friction-free positioning of the machine, fixture and part components being transported. In the case of axis drives, dual guides are mandatory. Further the system should use contained lubrication that does not require on-going application of lubricating grease that is subject contaminated do to exposure to the elements. Additionally quality DMC's liner guide systems contain a pre-load block for greater consistency and increased accuracy.

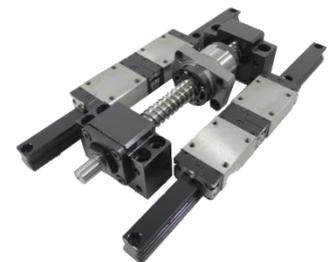
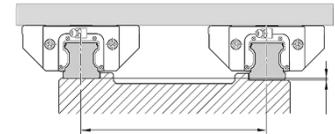


Figure 2 Dual linear guide system with ball screw



Figure 3. Rear view of the Versamill 4X-100 showing cast aluminum-alloy castings linear guide ways

The method of traverse can be through rack-and-pinion, lead screw, ball screw or the least preferred, cable and pulley system. Quality DMC's utilize ball screws-period!

A ball screw is a mechanical linear actuator that translates rotational motion to linear motion with little friction. A threaded shaft provides a helical raceway for ball bearings which act as a precision screw. As well as being able to apply or withstand high thrust loads, they can do so with minimum internal friction. They are made to close tolerances and are therefore suitable for use in situations in which high precision is necessary. The ball assembly acts as the nut while the threaded shaft is the screw. Low friction in

ball screws yields high mechanical efficiency compared to alternatives. Lack of sliding friction between the nut and screw lends itself to extended lifespan of the screw assembly (especially in no-backlash systems), reducing downtime for maintenance and parts replacement, while also decreasing demand for lubrication.

One phenomena that occurs with any screw and nut base system is backlash. Backlash is any non-movement that occurs during axis reversals. The problem with backlash is that it can impose positioning error in a positioning system. For example, if the screw in figure 3 has five teeth per inch (5 TPI) and you

turn the screw five times so that the nut moves to the right, the nut will move exactly one inch to the right. But starting from the position of the nut in figure 3, if you turn the screw five times so that the nut moves to the left, the nut will move one inch minus the amount of backlash. This is because the initial turning of the screw takes up the backlash but does not move the nut. The nut only moves after the screw has turned enough so its threads are bearing on the right side surfaces of the nut threads.

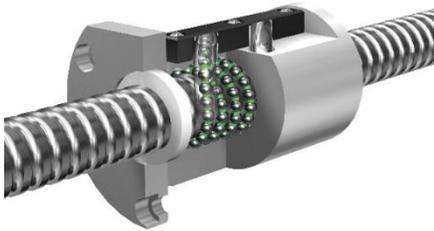


Figure 4. This cutaway drawing of a THK SBN ballscrew shows the main components of a typical ballscrew including the screw itself, a nut and the balls, which roll between the nut, screw and grooves.

In cases where the amount of backlash is known and it is *always* known which side of the screw thread is contacting the nut thread, it is possible to simply subtract out the backlash where appropriate. This is the essence of software backlash compensation, which is offered by some of the computer software available to drive Computer Numerical Control (CNC) machines.

Most backlash reduction schemes employed by quality DMC's involve mechanical pre-loading of the nut for movement in both directions. In the examples above when the screw was actually driving the nut and carriage, the screw was driving the load of the carriage assembly. If it starts turning the other way it is unloaded until the backlash is taken up, at which point it begins driving the

load of the carriage assembly the other way. Preloading, that is, imposing a load on both sides of the screw thread simultaneously even while it is not moving means there is never backlash that needs to be taken up.

AXIS MOTOR CONTROL SYSTEMS

CNC systems require motor drives to control both the position and the velocity of the machine axes. Each axis must be driven separately and follow the command signal generated by the CNC control. There are two ways to activate the servo drives: utilizing a open-loop system or a closed-loop system.

Open Loop: Programmed instructions are fed into the machine controller through an input device. These instructions are then converted to electrical pulses (signals) by the controller and sent to a servo amplifier to energize the servo motors. The cumulative number of electrical pulses determines the distance each servo drive will move, and the pulse frequency determines the velocity.

The primary drawback of the open-loop system is that there is no feedback system to check whether the program position and velocity has been achieved. If the system performance is affected by load, temperature, humidity, or lubrication then the actual output could deviate from the desired output.

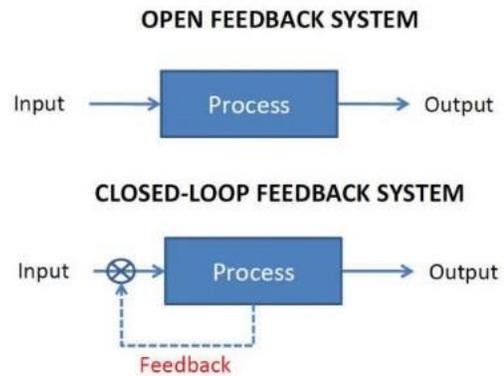
- Industrial Strength Machine Designed for Minimum Foot Print & to Fit Through Standard Size Door Opening
- Safety & Operational Features for Lights-out Machining
- Flexibility to Machine Any Material in Any Form Factor
- Highly Detailed Restorations with Superior Margins, Less Scrap and Minimum Benching
- 5-Axis Machining Minimizes Stock Thickness and Machine Time
- 5-Axis Allows machining of Abutments & Dental Bars in the True Insert Direction
- Rigid Machine Structure for Minimum Machine Vibration
- High Power Spindle Enables Efficient Machining of High Strength Materials & Very Small Tool Radii
- High Precision with 5 micron Positional Accuracy

Closed Loop: The closed-loop system has a feedback subsystem to monitor the actual output and correct any discrepancy from the programmed input. The feedback system could be either analog (resolvers) or digital (linear scales). The analog systems measure the variation of physical variables such as position and velocity in terms of voltage levels. Digital systems monitor output variations by means of electrical pulses

Closed-loop systems are very powerful and accurate because they are capable of monitoring operating conditions through feedback subsystems and automatically compensating for any variations in real-time.

Most modern closed-loop CNC systems are able to provide very close resolution of 0.0001 of an inch. Closed-looped systems require more control devices and circuitry in order for them to implement both position and velocity control. This makes them more complex and more expensive than the open-loop system.

A servo based control system does allow for much smoother operation while offering the benefits of comparing and providing real time positional accuracy. Servo based system also have an added advantage of consistent torque at faster cutting speeds, critical in high speed machining applications.



THE IMPORTANCE OF GOOD FIXTURING

The quality and the performance of the mass production cycle is influenced by jigs and fixtures as they responsible for the placing and holding of a component.

Good jigs and fixtures provide dental manufacturing professionals the following:

- A higher degree of positioning precision and the repeatability thereof.
- A greater accuracy for the positioning of precise hole centers.
- Tighter tolerances at micron levels with higher-quality surface finishes.
- A faster time frame to achieve these tolerances.
- Increased cutting tool life.

Some of the advantages associated with a good jig and fixture include:

Productivity:

Good jigs and fixtures are able to effectively increase productivity. This is because the part, during manufacturing, does not have to be frequently checked and eliminates the need for individual marking and positioning.



Figure 5. Versamill 5X-200 Universal Fixture offering complete stability and versatility. Notice fully-supported fixture held on both ends with precision cartridge inserts to enable quick change-over to different rough stock forms.

Costs:

Because of an increased productivity, a reduction in waste material, a lesser use of manual labor and the easy assembly offered through using precision machining technologies, the cost of production is considerably reduced.

Interchangeability:

Using precision jigs and fixtures in manufacturing processes ensures a uniform quality. Selective assembly is eliminated as any part of the machine fits properly and are interchangeable.

Skills:

The need for a skilled work force to position tools correctly is severely minimized as the locating, clamping and the correct positioning of the work piece is done by tool guiding elements. Semi-skilled operators can be employed.

Quality

The variability of dimensions in mass production cycles are lower, as good jigs and fixtures limit vibration and are able to maintain a quality that is consistent.

OTHER CONSIDERATIONS

Aside from the CAM software utilized and the vendor you choose to purchase a DMC from (both of which play a more than a significant role in supporting you in operating and maintaining your investment in digital dental technology) some other considerations are:

Wet and/or Dry Machining: There are many misconceptions regarding the pro's and con's of wet machining zirconia as well as problems associated with switching from dry machining to water-based to bio-fluid based coolant. These misconceptions are likely based on early DMC's or those that fall on the lower end of the price/quality spectrum.

Wet machining zirconia, though adding an additional drying phase to the workflow, has proven to be an effective alternative to dry machining as it eliminates the need for the expense and maintenance of vacuum and filtration systems while completely eliminating the caustic and abrasive dust swag produced as a result of the machining process- thereby extending the life of the DMC.

There are no problems with switching between these three types of dental prosthesis machining in a quality DMC. A quality DMC will provide completely isolated cooling systems so as to not cross-contaminate any one system. This requires each delivery system have their own filtration and delivery systems. Additionally, a change-over from one system to another should be able to be accomplished in less than 10 minutes time.

Automatic Tool Changer (ATC): The number of tools that an ATC can hold should be considered in as much as there should be adequate capacity to support the number of cutting tools utilized by the machining templates of your CAM software. There should be sufficient capacity to suite both your long and short term objectives. To facilitate extended runs or "lights-out" operation additional tool capacity to allow a doubling or tripling up of tools is beneficial if the CAM system utilized can facilitate additional tool changes to account for tool wear.



Figure 6. Internal view of the versamill 5X-200 showing use of precision ballscrews w/anti-backlash nut, large way-surface with linear guide and protective coverings. All elements found in "large-format" high-speed industrial machines but less common in a DMC.

The ATC system should also provide automatic tool length compensation and detect broken or missing tools during a tool change operation and take appropriate action should those conditions exist.

Tool change time, while important, is of greater concern in high production environments and should always be measured “chip-to-chip”. That is, from the time the cutting tool stops cutting, until the time the cutting tools is again engaged in the cut. The only real important measure of machine time is overall time to actually provide a finished machined product; so if it take a few seconds longer to facilitate a “chip-to-chip” tool change but the overall cycle time is shorter-going with the shorter cycle time is usually a good choice.

Automatic Disc/Puck Changers: These devices used to automate the machining process and provide extended machining operation (output) are typically only effective in moderately high production environment as they have been known to be problematic and unreliable in operation. They can however be convenient to provide a faster/automated changeover from raw stock forms of varying thickness (as compared to a manual method).

If provided as part of or as an option with a high quality DMC they will typically require a significant investment and in many cases be substituted with some form of high-quality robotic or part transfer cell that is significantly more reliable and require less maintenance.

Careful inspection of disc changing mechanisms is a must when assessing the value of this type of automation device to assure the solution incorporates a reliably functional design with adherence to quality construction guidelines utilizing high quality parts. Without such an examination (including historical information regarding reliability/functionality) the additional cost associated with it may only serve to provide another potential fail-point and interject additional undesirable consequences such as down-time, maintenance and repair costs.

Open Source: Your choice of a DMC should always be an Open Source machine. It should be supported by a wide variety of CAM software including that which is currently utilized or likely to be utilized in the future. Additionally, a discussion over post-processor availability and or development assistance in creating a post-processor for a given DMC/CAM software should take place immediately upon investigating the effectiveness of any given DMC.

Machine Control: The machine control is of utmost importance. It is the Operating System or the brain of the machine and its performance is critical. A control with maximum block processing rate will ensure that the received data will be handled quickly and efficiently. This data should reside on a hard-drive located on the control. Incorporating numerical algorithm to calculate the velocity profile in the control will assist in smoothing machine motion.

In today’s high-speed, high-efficiency machining environment it must meet many requirements, including:

- Open Systems Architecture
- Open to integration/automation at the user level
- Have extremely fast block execution times
- Look ahead feedrate control over more than 100 blocks
- Transformations, e.g. for clamping corrections or 5-axis transformation
- Elimination of contour error in the axes to provide greater path accuracy
- Torque damping along the feed path and in an axial direction to reduce machine wear
- Tool correction (length, radius, various types of cutter)
- Compensation for mechanically induced errors

KNOWLEDGE IS POWER

The cost of owning a Dental Machining Center is not determined by its initial selling price alone. A high quality DMC will save its owner far more money during its useful life in the reduction of; tooling costs, re-worked restorations, hand work, parts replacement and down-time than any up-front cost savings at time of purchase. Selecting the right DMC is not as difficult as you may think...you just need to know what to look for.

Following the guidelines presented here will help you make more informed decisions about which machine best fits your needs and the value one machine may have over another.

You will soon realize why there is a significant difference in price between various DMC's under consideration. Much of the criteria here is not published on manufacturer's website, their promotional material or product brochures. It is up to the consumer to ask the pertinent questions for which a vendor may not know the answer to, does not want to necessarily share the answer or knows how their machine compares in the critical areas presented here; but don't be afraid to ask.

Versamill 5X-200

Open Source, Quality Construction, High Reliability



15-position ATC w/auto length compensation & breakage detection.



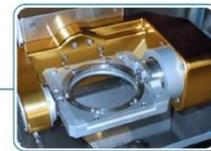
Closed-loop servo drives, linear guides & ballscrews provide stability & smooth accurate motion



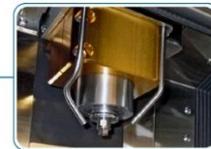
Aluminum-alloy castings & high-strength steel for structure provide outstanding machine dynamics.



Rigid rotary axes with a full 30° rotation holds the universal fixture that accommodates both zirconia and metal blank discs.



Heavy duty spindle assembly with dual flood coolant nozzles for isolation of cutting fluids and complete saturation of the cutting tool and workpiece.



Dust collection shroud. Included with dry-machining option.

Separate coolant tanks makes for easy change over from zirconia to other materials without compromising the integrity of the fluids.



Acknowledgments:

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CNC Control - 3: Open and Closed Loop Control