AMTI Ortho-Pod instrumentation

MACHINE DESCRIPTION

The AMTI Ortho-POD shown in figure (1), was used in this study consists of two basic assemblies, the top head and the base. The top head contains six independent pin actuators located on a 2.062 in. (5.2 cm) radius with respect to the base disc drive axis. All the pins undergo the same rotary motion. Each of the pin load actuators also provides an identical load range is 0-100 lbs. (0-450 N) but any pins can be turned off individually. The base contains single base disk drive axis and generally six disk specimens are mounted on a main drive disk at appropriate radii. Collet-type pin holders can be attached directly to the pin actuator shafts or the pin holder can be offset from these shafts 1.00 in (2.54 cm) by using the offset pin holders provided. The machine has three independent servo-controlled motions that correspond to the pin rotary motion, the plate rotary motion and the normal loads on the six pins. Each of the six pin drive axes is centered on a planet gear which is driven by a single sun gear through a backlash-free harmonic drive gear head. A brushless DC motor drives the gear head. AMTI multi-component force sensors measure the three force components (F_x, F_y, and F_z) at the pin-sample disk interface. The machine is supplied with a PC, however, the machine also contains a waveform board that has fixed microprocessor. The PC is used to program a desired waveform which is then moved to the waveform board. The Ortho-Pod is designed to simply sit on a level surface and is most easily used on a table height surface. This surface must be rigid if the force transducer option is provided because table vibrations are easily picked up by the force transducers. The machine has two utility requirements, power and air.[m]

Figure 1.The upper image Show AMTI Ortho-POD WITH three basic parts, the Ortho-Pod itself, a computer system (Processor, Monitor, etc.) to the left, and a recirculating temperature control unit to the right. The lower image show the pins and disks. [3]

An air supply of 6 standard cubic feet per minute (170 standard liters per minute) of 90 psig (6.2 bar) clean, dry, and filtered air is required the pressure gauge always must be check to ensure a probable pressure reach the actuators the gauge located behind the device as shown in figure (2).

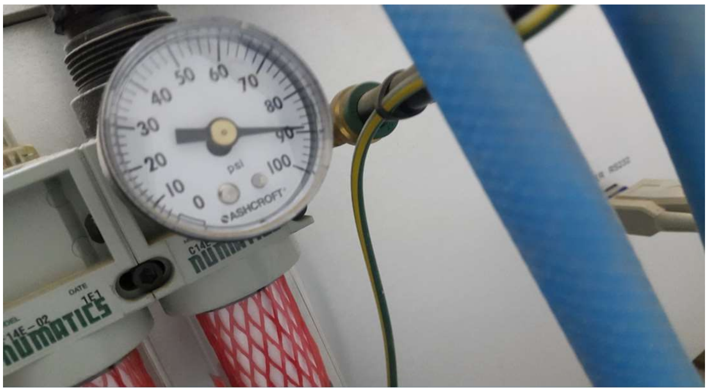

Figure 2. pressure guage of The AMTI Ortho-POD

Programming the waveform

Two main waveforms programmed during the tests square and circle. AMTI's pin-on-disk machines have three independent mechanical actuators providing independent control of vertical load, pin rotation and disk rotation. The system works as follows. First the supervisory software on the PC downloads a waveform template to the Waveform Generator. Each waveform template encodes the three signals necessary to produce one cycle of motion for the machine's mechanical actuators. The Waveform Generator's embedded controller reads the template data and performs an interpolation algorithm to provide smooth real time wave generation. The interpolated digital signals are in turn fed to a digital to analog converter which provides the desired time varying analog output voltages or waveforms. These analog waveforms are then fed to the servo control loop circuitry where, along with the proper feedback signals, they are conditioned to provide the driving signals for the force and rotation actuators[m]. Waveform template generated by the following steps. First the wave shape sketched on the paper and the number of points determine the accuracy of the shape more point means more accurate shape, then paper fixed on one of the disk with tape as shown in figure (3).

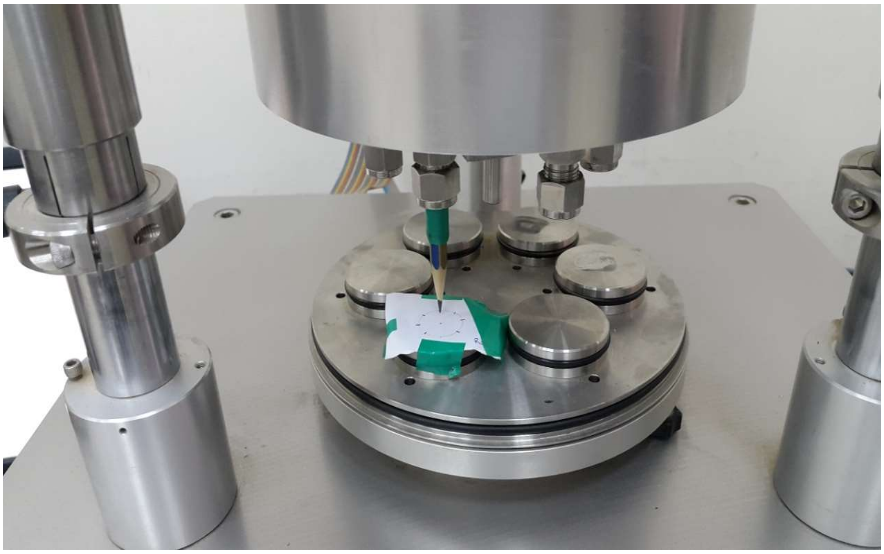

figure 3. show pencil attached to pin holder during the waveform programming at biomechanical lab of AL-Nahrain university.

Pencil is put on pin just above the sketch paper, then The "Manual Mode" provides a control panel like interface with push buttons used to actuate the machine's servo actuators as shown in figure (4). Finally after finishing all the points and enter the desire load for the wave The POD software includes a utility program, the "Template Editor" which facilitates programming the system. The "Template Editor" utility provides the tools necessary to convert user data (generated by manual mode), in the form of ASCII text files, to machine readable waveform template files. The template editor show in figure (5)

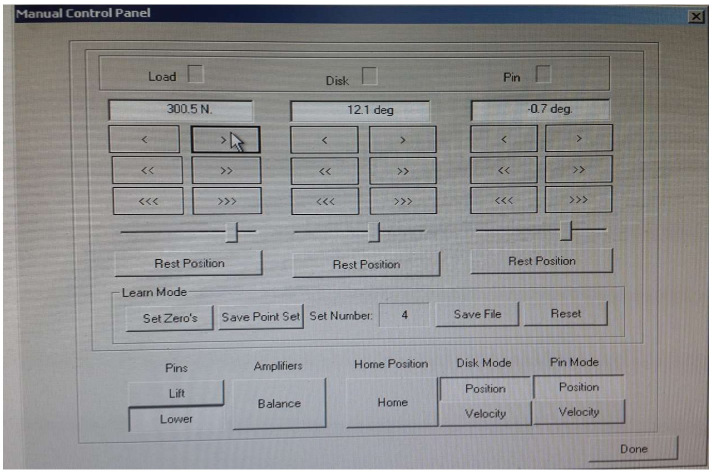

figure 4. the image show the manual control panal the load and other specification for drawing the desire waveform controlled by this panal.

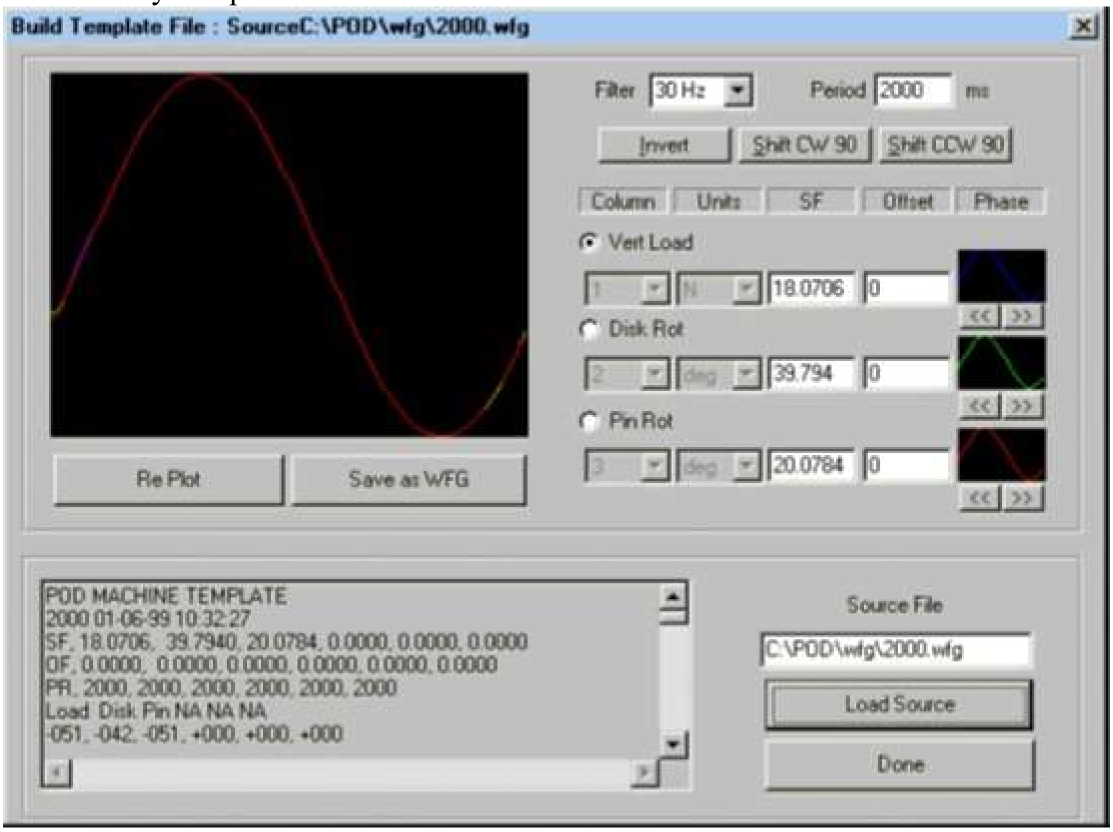

figure 5. image show the last panal template panal used in programming the waveform this panal converted the waveform which is programmed preveiosly to machine readable waveform template files.

after the programming of wave finish the system is now ready to use by entering the mointor mode panal. In the "Monitor Mode" the POD software runs user programs which schedule the machine's activities by downloading waveform data to the embedded controller. The programs also provide the means to synchronize data acquisition with the waveform processes. While the "Monitor Mode" is running the POD software also plays a supervisory role by interrogating the embedded controller to detect system faults and other control conditions as shown in figure(6).

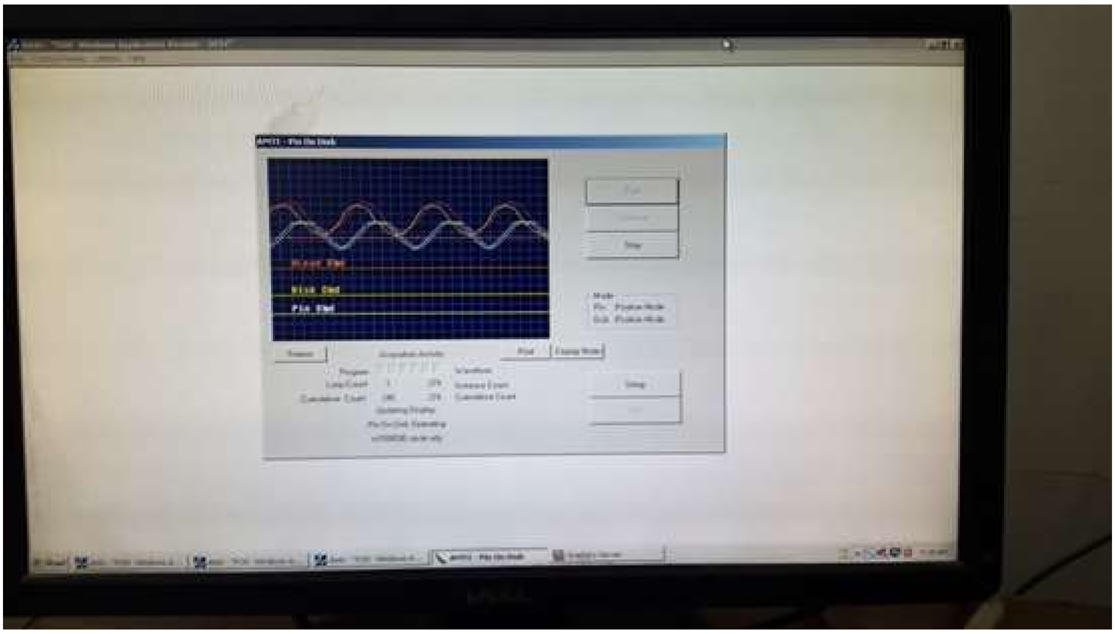

figure 6. a AMTI monitor mode panal, its very important real time monitoring for operating and checking the state of AMTI machine during tests.

Experimental materials for pins

UHMWPE

Polyethylene is a polymer formed from ethylene, which is a gas. The generic chemical formula for polyethylene is $-(C_2H_4)_n-$, where *n* is the degree of polymerization. There are several types of polyethylene (LDPE, LLDPE, HDPE, UHMWPE), which are produced with different molecular weights and chain architectures. (UHMWPE) is an exceptional polymer with outstanding physical and mechanical properties. Most notable are its lubricity, chemical inertness, impact and abrasion resistance. UHMWPE has been utilized in orthopedics as a bearing material in artificial joints For the past 45 years. The UHMWPE used in orthopedic implant is a kind of *polymer* generally classified as a *linear homopolymer*. [kurtz handbook]. polyethylene is subject to oxidation and halogenation. Chemicals like nitric acid produce oxidative deterioration and affect mechanical properties of polyethylene. The environmental oxidation of polyethylene happens at high temperature, under ultra-violet light and/or high energy irradiation, e.g., gamma irradiation. Polyethylene should be kept from contact with halogenating agents and environments. The lower molecular weight polyethylene may be dissolved at high temperature and swollen by chemicals such as benzene and xylene. The resistance to environmental stress cracking (ESC) increases with molecular weight.[jonathan black]
polyethylene is to proceed from ideal abstractions to actual physical implants, three real-world steps need to occur. First, the UHMWPE must be polymerized from ethylene gas. Second, the polymerized UHMWPE, in the form of resin powder, needs to be consolidated into a sheet, rod, or near-net shaped implant. Finally, in most instances, the UHMWPE implant needs to be machined into its final shape as shown in figure (7).[kurtz handbook].

Figure 7. Typical processing steps in the manufacture of UHMWPE implants, starting with the resin powder (A). (B) Semifinished rods that have been consolidated from the resin powder; (C) Machining of the UHMWPE rods on a lathe; (D) UHMWPE acetabular components after machining. Pictures provided courtesy of David Schroeder (Biomet, Inc., Warsaw, Indiana, USA). [kurtz handbook].

The UHMWPE used in this study was imported from the USA and the properties as shown in the table (1).

Table (1): Properties of UHMWPE

Color	White	
Shape	Round Rod Outside Diameter	3/8 inches
Overall Length	1 feet	
SpecificationMet	ASTM D4020 Features	
FDA Compliant		

Acetal copolymer

Polyacetal can be divided into two main kinds, Acetal homoploymer and Acetal copolymer. Delrin (1959) was the first trademark for this polymer by Du Pont Company. The copolymers were introduced by the Celanese Corporation of America, and the first commercial product named Celcon (1960). One of the major advantages of copolymerization is to stabilize Polyacetal because the homopolymer trend to depolymerize and eliminate formaldehyde. As can be seen Polyacetal has a simple structure of a polyether. Unlike polyethylene, Polyacetal has no branching, and its molecules can become more closely together than those of polyethylene. Polyacetal is thus harder and has a higher melting point than polyethylene. Generally, the polyacetals have the following characteristics, a. High tensile strength, shear strength, stiffness, and toughness, b. Predictable stress/ strain relationships, c. Predictable dimensional behavior, d. Abrasion resistance, e. Chemical and

Corrosion resistance, f. Light weight and good appearance, g. Acceptability for food contact application (most grades), h. Ease of processing, and i. Competitive costs.
Water can not degrade it but may swell it or permeate through it and affect the dimensions of its products. Prolonged exposure to ultra-violet light will induce surface chalking and reduce the molecular weight of the polymers. Polyacetals, both homopolymer and copolymer are also radiation sensitive. The radiation damage threshold is estimated at 0.5 Mrad [jonathan black].
There has been a recent resurgence in the development of polyacetals for a wide range of biomedical applications ranging from drug delivery to tissue engineering. However, polyacetal has been used as an orthopedic implant and as an orthopedic implant-coating material to interface with bone tissue as this polyacetal has a similar modulus to bone. Ultrasound is used in the diagnosis of osteoporosis and porous polyacetal blocks were found useful to gain insights into bone porosity and ultrasonic properties[kumber]. The Acetal copolymer used in this study was imported from the USA the properties shown in Table (3).

Table (3): Properties of Acetal copolymer

Color	Black	
Overall Length	24 inches	
Length Tolerance	+0.000/- 0.187 inches	
Outside Diameter	3/8 inches	
Lower Temperature Range	-20 Degrees Fahrenheit Exterior Finish	Smooth
Indentation Hardness	89Rockwell M Tensile Strength Max	
	9500 PSI Specification Met	
ASTM D6778		

Samples preparation

pin samples

Each sample rod was cut by PVC cutter as shown in figure (9.a) into six identical cylinders is simply a 0.375 in (0.953 cm) diameter by 1.2204 in (3.1 cm). The pin samples were cut from UHMWPE, PEEK and Acetal copolymer rod as shown in figure (9.b). AMTI is a special six-station pin-on-disk, therefore, for each test, a group of six samples of the same materials used.

figure(9) show the cutting process of the samples a:the tools used for the cutting included ruler, pencil, cutter , pvc cutter and belt to fix the sample and prevent movement during cutting.
b:show three samples after cutting UHMWPEto the right, PEEK in the middle and Acetal co polymer to the left.

Disk samples

Six 316 Stainless Steel It consists of a 1.5 in (3.81 cm) diameter by 0.5 in (1.27 cm) thick metal plate as shown in figure (10). Disk brought from AMTI lab, Watertown, USA.

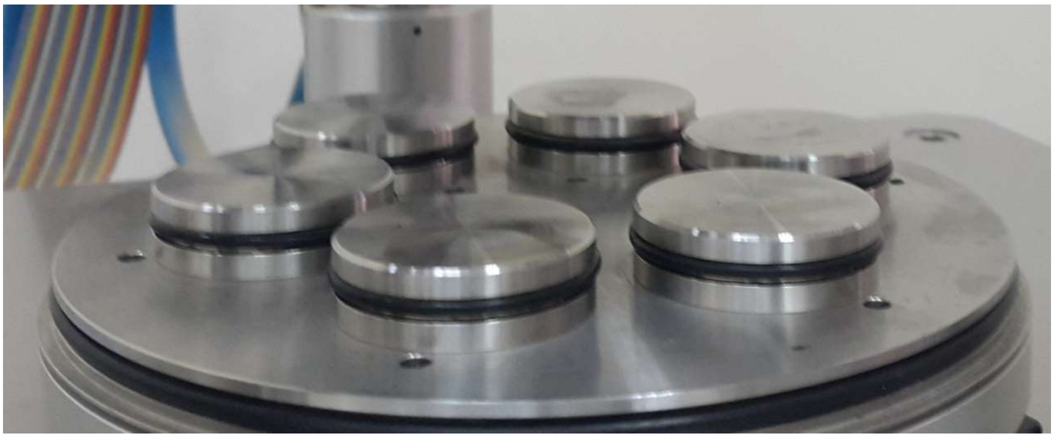

figure 10. Show the six 316 stainless steel disk

Experimental procedure

Wear and friction testing was performed on a six-station pin- on-disk (AMTI Ortho-POD) in the biomedical engineering department lab of AL-Nahrain university in Baghdad. Each wear test was comprised of six pins, each subject to a fixed load, moving periodically on its own metal disk. The cylindrical UHMWPE polyethylene pins sliding against polished 316 Stainless Steel disks in the first four tests. The cylindrical peek and Acetal copolymer pins sliding against highly polished 316 Stainless Steel disks in the test 5 and 6. In the study of UHMWPE wear several comparisons were made:
1-by changing the waveform of wear path and keep other parameter constant. 2-by changing the loads applied to pin and disk and keep other parameters constant. 3-by changing the material types and keep other parameter constant. A square motion pattern, which consisted of a 10mm on a side path program used machine software. The length of the side was selected to match the long dimension of the wear path reported for the path traced by the femoral head on the acetabular cup [D. Mazzucco and M. Spector]. A square wave was programmed by four points and the circular wave was programmed by 8 points and the radius (5 mm) after that converted to the template file ".wav". Each waveform template encodes the three signals necessary to produce one cycle of motion for the machine's mechanical actuators [m]. Each test was performed for 0.25 million cycles complete in 10 days and each day performed 25,000 cycles. The Time required to complete a full test was 35 hours. During testing, friction was determined every 50,000 cycles for each station using 6-DOF load cells. Pins were cleaned and then weighed using a high-precision balance every 50,000 cycles in the chemical engineering department lab of AL-Nahrain university in Baghdad as shown in figure (11). Cleaning of the pins materials (UHMWPE, PEEK and Acetal copolymer) involved careful wiping with tissue soaking with ethanol absolute with ASSAY (99.9%) before weighting the full properties of ethanol show in figure (12).

figure 11. Show pin sample weighting with high precision four digit balance 0.1 mg any air flow or movement can change the reading measurement so the balance provided by glass chamber closed during work to prevent any error during measurement.