Variorum, Vol.-01, Issue-II, November 2010

Technological Innovations in Progress of Pole-vault Performance

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Introduction

Pole-vaulting was not one of the original Olympic sports in ancient Greece. Some think that the sport was derived from the Dutch habit of dyke-jumping, although one of the earliest pole-vaulting stands was built in Germany in 1791. The objective is, obviously, to get the athlete's centre of mass over the highest bar possible. However, today's pole-vaulters use a quite different technique to that used 100 years ago, when athletes went over the bar with their feet pointing downwards. Athletes now do a complex gymnastic manoeuvre, turning upside down as the jump takes place. We shall see that this is a direct result of the technology used.

Pole Construction

Modern fiberglass vaulting poles are manufactured from 3 pieces of S – type fiberglass i.e. Epoxy resin which is used for elastic properties. Fiberglass cloth tape is wrapped in a spiral round an aluminum template and then reversed for a second layer. The spiral tape gives strength around its circumference. The outer most layer is called the Sail piece .The sail piece is wrapped from the base so that less fiberglass is laid at the top and bottom of the pole. This procedure reduces the weight of the pole by eliminating fiberglass from the region where strength is not required. Finally, the pole is heated at 165°C. "Flex No" is determined by supporting the pole at two points i.e. 6″ from the bottom, 18″ from top and 50 pounds at mid of the pole. World class vaulters uses the deflection about 13 cm and 24cm.Elite vaulters uses their pole **5-20kg** above their body wt.

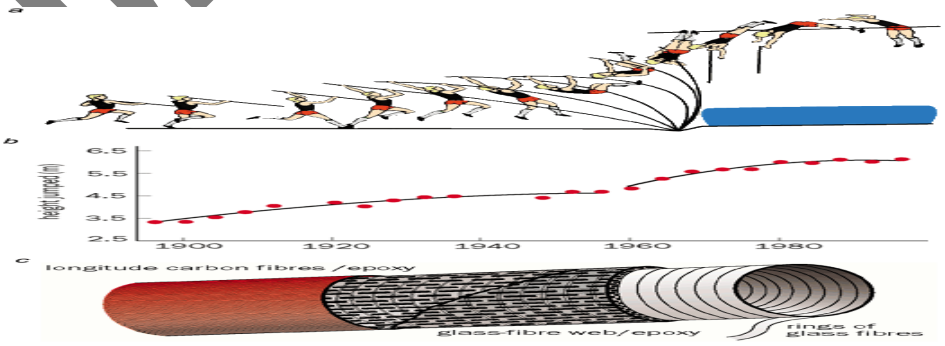

Figure .1 Pole Constructions

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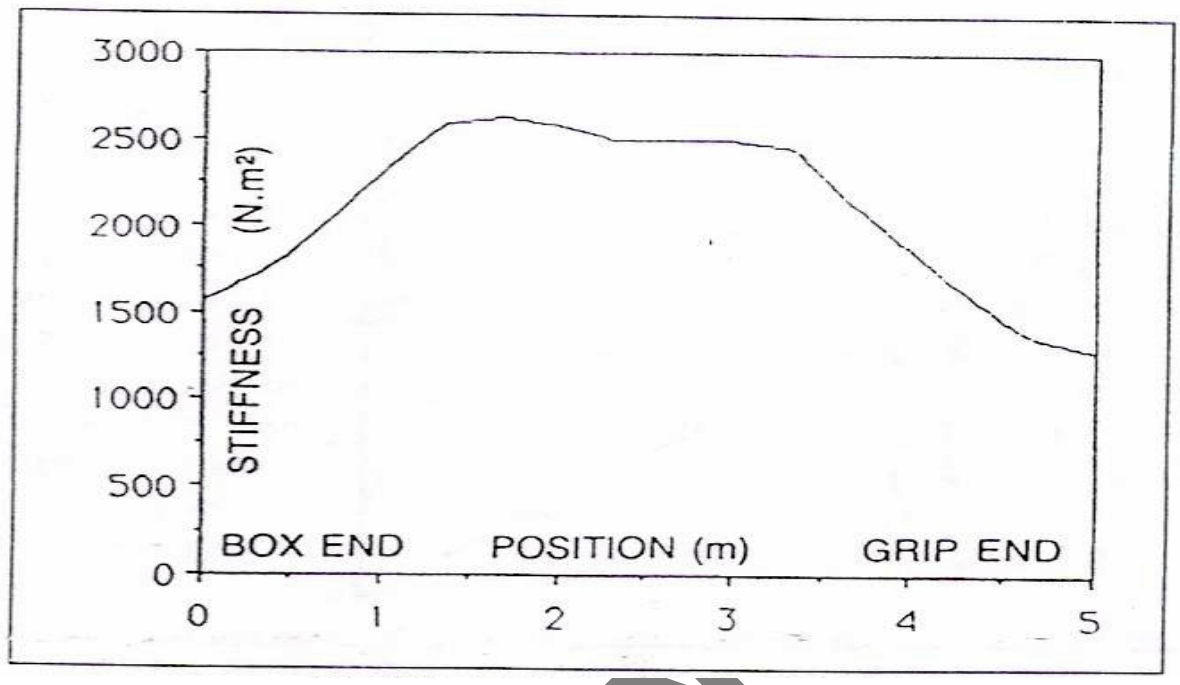

Figure.2 Flexular Stiffness of a Pole

Selection of Pole

Pole classified by its Buckling load .Buckling load is the amount of load applied inward along the long axis of the pole which causes to bend the pole. E.g. 160 lb vaulter because of his velocity and technique who will be getting 200 lbs as pole is planted and to keep the pole bend .At the time of maximum bend Vaulter's weight is not sufficient to keep the pole bent .So Pole gives back energy when an athlete applied in pole plant and take off.

Handhold Height

Handhold height of vaulter at 14′the buckling load is 200 lbs. At 13′ Bucking load is 230 lbs which will be too stiff and it is very difficult to bend the pole where as at 15′the Bucking load is 175 lbs will be too soft .sometimes pole will be break. Every fiberglass pole has great buckling load ranging depend on the height of the hand hold .Buckling is Very high at low hand hold height and low at high hand hold height. Pole manufacturers simplify pole selection by combination of body wt., handhold ht. and an avg. of take off velocities. But still vaulters are selecting the pole by trial and error method whose take of velocities are differ.

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Selecting the Optimum Grip Height and Pole Stiffness

POLE BEND	PENETRATION		
	NOT ENOUGH	PERFECT	EXCESSIVE
SUB - MAXIMAL	lower grip on softer pole	same grip on a softer pole	Higher grip on the same pole
MAXIMAL BEND	Lower grip on a pole with the same stiffness	OPTIMIUM GRIP HEIGHT AND POLE STIFFNESS	Higher grip on a pole with the same stiffness
OVER -BEND	Lower grip on the same pole	Same grip on a stiffer pole	Higher on a stiffer pole

Figure.3 Selecting the Optimum Grip Height and Pole Stiffness

Grip Heights, Run-up Velocities and Performance of World Class Pole Vaulters

NAME	GRIP HEIGHT(M)	RUN UP VELOCITY(M/SEC) (10 -5 M)	PERFORMANCE(M)
SALBERT(FRA)	5.20	9.29	5.55
VIGN ERON(FRA)	4.92	9.38	5.50
GATAULLIN(USSR)	5.10	9.80	5.80
KOLASA(POL)	5.05	9.25	5.80
TAREV(BUL)	4.95	9.29	5.60
NIKOLOV(BUL)	4.85	9.31	5.70
BUBKA(USSR)	5.17	9.77	5.85

FIGURE .4

Advantages of Fiberglass Pole

In fiberglass pole, shock is very less at pole plant and takes off and less energy lost at pole plant and take off when compared to other poles. Fiber has greater take of velocity. Steel pole grip at 3.80m - 4.20m (Ganslen 1961) where as fibre pole grip at 4.80m.-5.10m.This 90cm difference is the direct result of the less energy lost at take off. In fiberglass much energy is converted to reach high above the ground.

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Mechanics of Pole - Vaulting

Main aim of vaulting is conversion of run up speed into height above the ground. For e.g. Athlete mass (m) is 80 kg , Running speed(v) = 10 m s^{-1}

Whose kinetic energy is $1/2mv^2$ =1/2X80X10X10=4000 j

If 100% of kinetic energy converted into potential energy [mgh]

m - Mass of an athlete

g - ā due to gravity

h - ht. jumped

mgh = **4000 j**

h = 4000j / 80 × g = **5m**

In reality most vaulters reaches the ht. of 6m .How could an athlete reach 6 m? It turns out that the extra energy comes from the athleticism of the vaulter bending the pole. Strained energy in the pole as it is bent or strained by the athlete muscles and returned to the vaults.

Max. Strain energy of the pole is $ms^2/2rE$

s - Maximum (or) failure stress

r - Density of the pole

E - Young's modulus [Stiffness]

Bamboo has low young's modulus, density and moderate failure stress. Glass fibre also has low young's modulus, density and higher failure stress. Max strain energy stored in the fibre - **1250j** Where as in bamboo **100j** .If Athletes would have both kinetic energy and strain energy will be **4000j + 1250j =5250j .**If all this converted into potential energy

mgh = 5250j

h = 5250/80×g = **6.5 mts .**

Athlete looses 25% of their run up kinetic energy during takeoff. If this energy is some have eliminated athlete would vault above 1.20 m higher [**McGinnis 1988**].The run up velocity of the leading vaulters has in recent years continually increased .the following development of the maximal velocity , according to several sources, has taken place: **1940:8.8.m/sec.;1948:9.15 m/sec.; 1964: 9.34 m/sec.;1969:9.5 m/sec,;1973:9.62**

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m/sec.;1988:9.90 m/sec . If the athletes more emphasizes and focuses on their later part of their run up whose performance might be progressed at the height of 6.5 mts.

Technological Improvement in Pole Vault Performance

In 1963 with the advent of aluminum, fiberglass, and graphite poles, the pole vault record shot up 2 ft (0.61 m) in three years and now stands at over 20'2 1/4" (6.14 m). Prior to that technological innovation, the pole vault record increased only about 2 in (5 cm) to 16 ft (4.88 m) between 1942 and 1960.

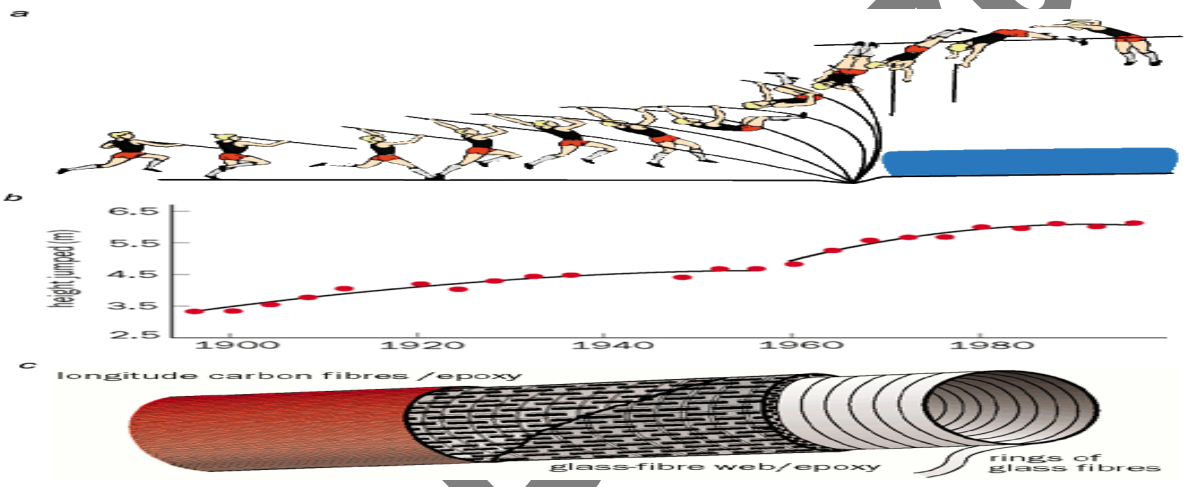

Figure.5 Technological Improvement in Pole Vault Performance

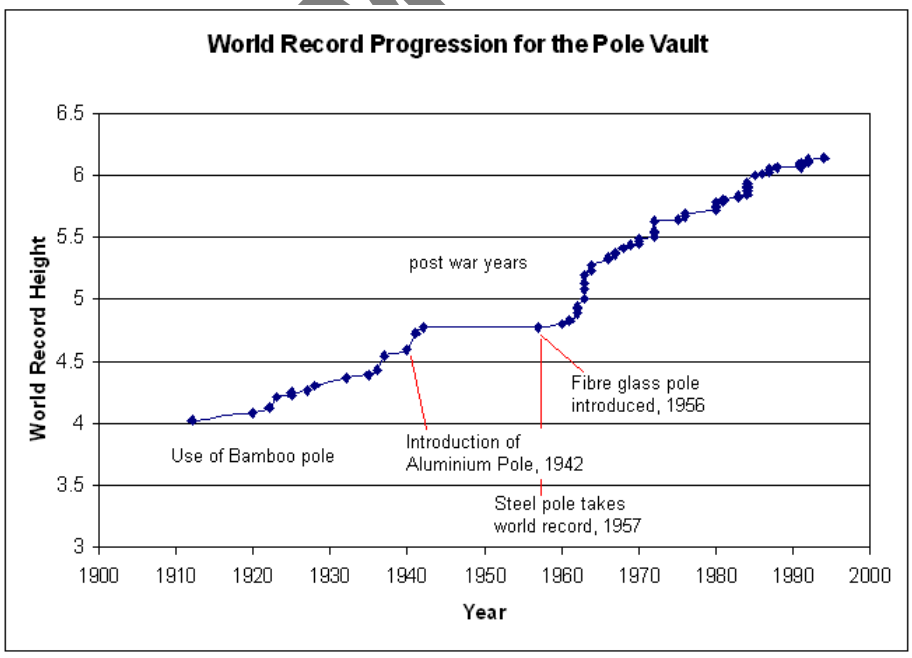

FIGURE.6

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Conclusion

Clearly, pole-vaulting is an example of a sport in which technology has been used to improve athletic performance. As the Olympic winning heights in the discipline level off, it will be interesting to see if our ingenuity can provide another technological leap to allow pole-vaulters to jump even higher. Advanced technology of the vaulting pole, running shoes, will make a lot of a difference in the future than it has in the past. Sports technology is not just limited to improvements in equipment. The modern-day athlete can now depend on computerized training systems to analyze their take off, swing, stride, and follow-through. When discussing technological improvements to sports equipment a distinction must be drawn between legitimate improvements and improvements that give athletes an unfair advantage-the equipment equivalent of performance enhancing drugs.

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