Computing pressure effect on projectile at an altitude 4Km above the sea level

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Abstract

In this paper the projectile was on altitude 4 Km above sea level ,Mach number change from 2-6 ,shock angle changing from 30 to 60 degree this angle depend on deflection angle which uses it .

Shock angle studying as oblique ,a smallest mach ,shock angle was 2 Mach and 30 degree because this value it is true for supersonic (normal component) so that this value is true for supersonic .by mathlab program increasing pressure with increasing Mach number ,shock angle ,by this know pressure values in figures on homing head can know suitable material type for it and altitude ,Mach number deflection angle .

Introduction

At standard sea-level conditions, $a =(k RT)^{1/2} = (1.4 \times 287 \times 289)^{1/2} = 341$m/s if assume the projectile was altitude 4Km this mean the temperature at this altitude equal to 263K°

$a=(1.4*287*263)^{1/2}=325.07$m/s this mean the velocity of sound decreasing with increasing altitude above sea level . Although the projectile speed did not change, the Mach number did change because of the change in the local speed of sound above sea level .

Bodies moving through a compressible fluid at speeds exceeding the speed of sound create a shock system shaped like a cone [1]. The half-angle of this shock cone is given by $\mu=\sin^{-1} 1/ Ma$

μ: half angle , Ma=Mach number

calculated the average transmission in seven 3-5 μ m and 8-12 μ m bands . Depending upon this calculations the attenuation in the first band is due to scattering and absorption of the aerosol and the carbon dioxide , were as the attenuation in the second ban is mainly due to the water vapor [2].

For finite negative or expansive flow deflections where the downstream pressure is less, the turning power of a single wave is insufficient and a fan of waves is set up, each inclined to the flow direction by the local Mach angle and terminating in the wave whose Mach angle is that appropriate to the downstream condition.

For small changes in supersonic flow deflection both the compression shock and expansion fan systems approach the character and geometrical properties of a Mach wave and retain only the algebraic sign of the change in pressure.[3]

Oblique Shock Waves

This angle is known as the *Mach angle*. The interior of the shock cone is called the zone of action. Inside the zone of action, it is possible to hear any sounds produced by the moving body. Outside the Mach cone, in what is known as the zone of silence, sounds produced by the moving body cannot be heard.

An oblique shock wave at angle β with respect to the approaching compressible fluid whose Mach number is supersonic is shown in Figure 1. Observe that the streamlines (parallel to the velocity vector) have been turned by the deflection angle(θ) by passing through the oblique shock wave.[1]

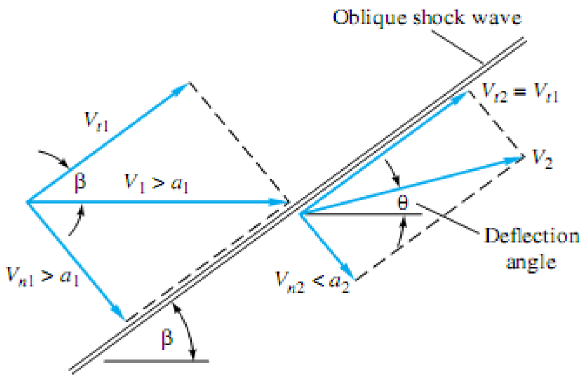

Fig (1) Geometry of flow through an oblique-shock wave

$$Ma_{n1} = \frac{V_{n1}}{a_1} = Ma_1 \sin \beta$$

$$Ma_{n2} = \frac{V_{n2}}{a_2} = Ma_2 \sin (\beta - \theta)$$

Man1=normal component for Mach number at shock wave
Man2= normal component for Mach number at deflection angle
Vn1= normal component for projectile flow in front of shock wave
Vn2 = normal component for projectile flow behind shock wave

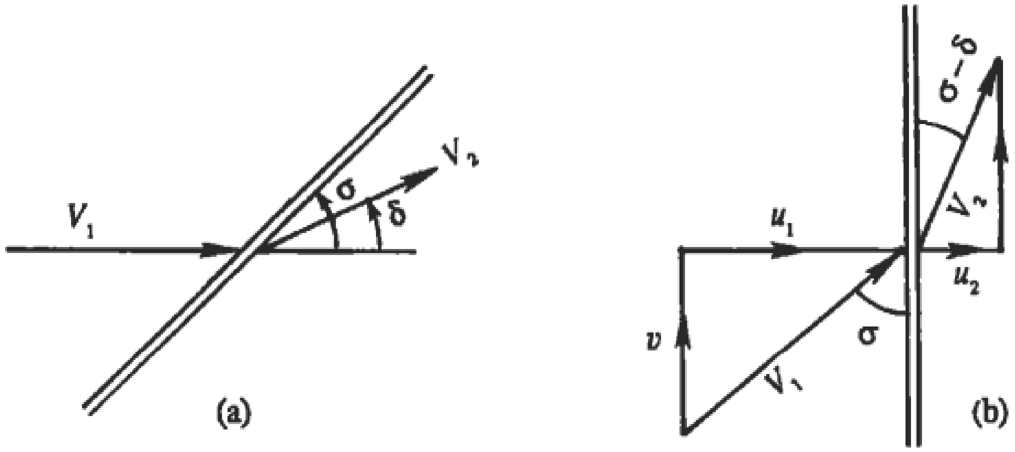

Figure 2 (a) oblique shock wave in which δ=deflection angle and σ=shock angle and (b)analysis by considering a normal shock and supersonic a velocity v parallel to the shock.

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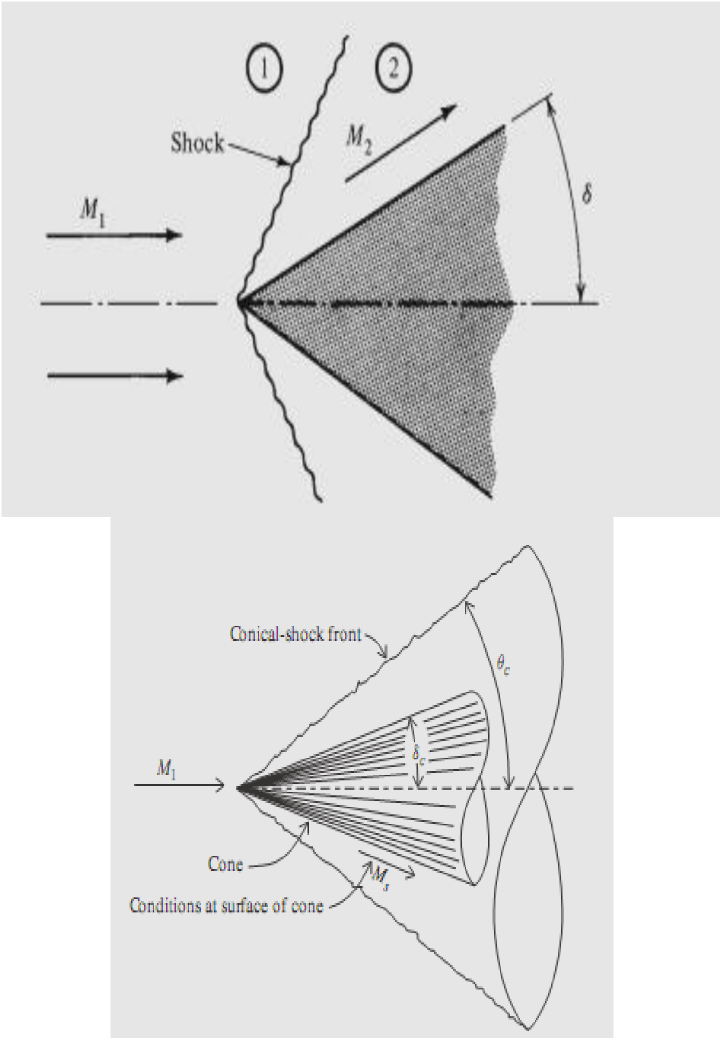
Boundary condition of flow direction

We have seen that one of the characteristics of an oblique shock is that the flow direction is changed. In fact, this is one of only two methods by which a supersonic flow can be turned.

Consider supersonic flow over a wedge-shaped object as shown in Figure 3 represent For example, this could the leading edge of a supersonic airfoil. In this case the flow is forced to change direction to meet the boundary condition of flow tangency along the wall, and this can be done only through the mechanism of an oblique shock. for any given Mach number and deflection angle there are two possible shock angles [3].

Thus a question naturally arises as to which solution will occur, the strong one or the weak one. Here is where the surrounding pressure must be considered. Recall that the strong shock occurs at the higher shock angle and results in a large pressure change. For this solution to occur, a physical situation must exist that can sustain the necessary pressure differential. It is conceivable that such a case might exist in an internal flow situation. However, for an external flow situation such as around it [3].



(a) (b)

Fig(3) a- supersonic flow over a wedge b- conical shock with angle definition

airfoil, there is no means available to support the greater pressure difference required by the strong shock. Thus, in external flow problems (flow around objects), we always find the weak solution [4] .

Relation between projectile and shock wave

Consider the supersonic flow past a wedge of half-angle δ, or the flow over a wall that turns inward by an angle δ (Figure 2). If *M1* and δ arc given , then σ can be obtained from equation

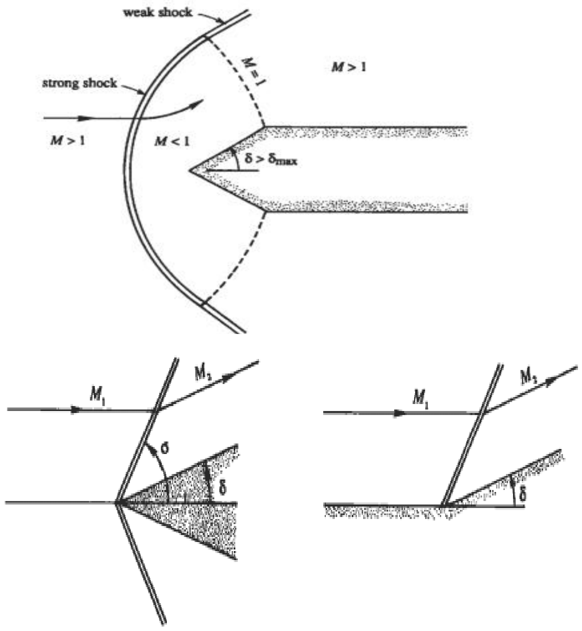
$$\tan\delta = 2\cot\sigma\,\frac{M_1^2\sin^2\sigma - 1}{M_1^2(\gamma + \cos 2\sigma) + 2}.$$

, and M_{n2} (and therefore $M2 = M_{n2}/\sin(\sigma - \delta)$) can be obtained from the equation

$$Ma_2^2 = \frac{(k-1)\,Ma_1^2 + 2}{2k\,Ma_1^2 - (k-1)}$$

The shock angle σ decreases to the Mach angle $\mu = \sin^{-1}(1/M1)$ as the deflection δ tends to zero. It is interesting that the comer velocity in a supersonic flow is finite. In contrast, the corner velocity in a subsonic (or incompressible) flow is either zero or infinite, depending on whether the wall shape is concave or convex. Moreover, the streamlines in Figure 2 arc straight, and computation of the field is easy. By contrast, the streamlines in a subsonic flow are curved, and the computation of the flow field is not easy. The basic reason for this is that, in a supersonic flow, the disturbances do not propagate upstream of Mach lines or shock waves emanating from the disturbances, hence the flow field can be constructed step by step, proceeding downstream. In contrast, the disturbances propagate both upstream and downstream in a subsonic flow, so that all features in the entire flow field are related to each other As δ is increased beyond δ_{max} attached oblique shocks are not possible, and a detached curved shock stands in front of the body (Figure 3). The central streamline goes through a normal shock and generates a subsonic flow in front of the wedge.

If the wedge angle is not too large, then the curved detached shock in Figure 3)[5].(



(b) (a)

Fig(3)oblique shock in supersonic flow(b)detached shock[3]

Can find the pressure after shock wave by this equation ,by using math lab program .so p1=static pressure at altitude h Km

$$\frac{p_2}{p_1} = 1 + \frac{2\gamma}{\gamma+1}(M_1^2 \sin^2 \sigma - 1),$$

The following average values are accepted by international agreement. Here, h is the height above sea level.

Table(1)

Variation of temperature and air pressure with altitude above sea level [6]

(h) Km	T (C)	air pressure (P) KPa
0	15.0	101.3
0.5	11.5	95.5
1	8.5	89.9
2	2.0	79.5
3	−4.5	70.1
4	−11.0	61.6
5	−17.5	54.0
6	−24.0	47.2
8	−37.0	35.6
10	−50.0	26.4
12	−56.5	19.3
14	−56.5	14.1
16	−56.5	10.3
18	−56.5	7.5
20	−56.5	5.5

Resulting and discussing

The mach number for all figures has 4 ,all figures Will discusses just at change mach number with pressure at altitude 4 Km a pressure was equal to 61.6KPa in this altitude ,in figure (4)was shock angle equal to 30° ,pressure equal to 64.4KPa ,figure (5) was shock angle (35º) ,figure(6)was shock angle (40º),figure (7) was shock angle (45º),and 50º,55º,60º in figures(8,9,10) respectively.

Denote in general all figures increasing pressure with increasing mach number shock angle,in figure (5) we note pressure 66.07 KPa at 4 mach ,but in figure (6) was shock angle (40º) the pressure equal to 67,65KPa at 4mach too ,but the pressure was 69.27 KPa in figure (7)so that at 4 mach, in figure (8)the pressure was 70.89KPa ,also the pressure on homing head projectile equal to (72.46,73.93)KPa in figures (9,10) respectively this reading was at 4 mach number as explain in figures ,and the projectile was altitude 4 Km above sea level ,the conclusion was : increasing pressure for projectile (homing head) with increasing shock angle and increasing mach number .This mean must choosing suitable material for homing head this material depend on physical properties or critic pressure and suitable design for deflection angle because the shock angle as function to mach number and deflection angle .

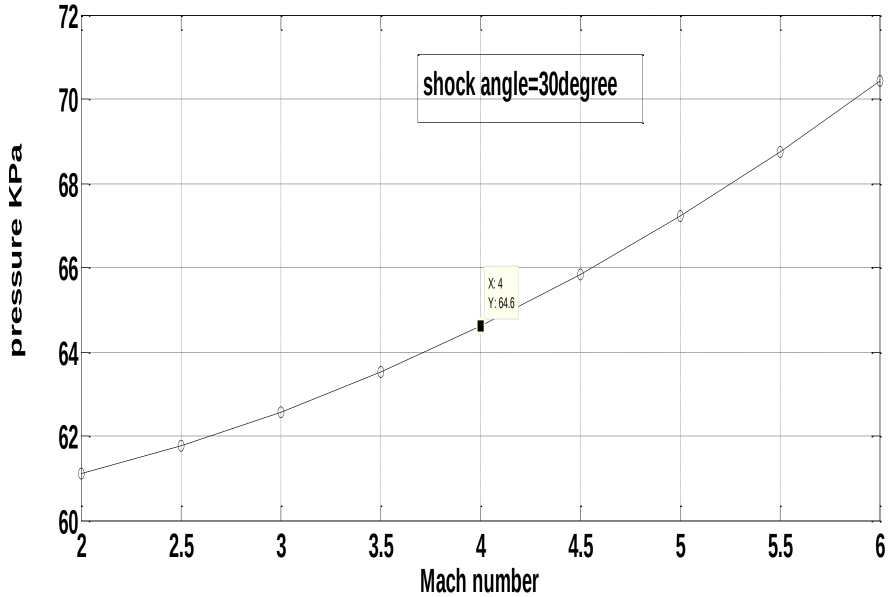


Fig (4) Explain relation between mach number and pressure at shock angle equal to 30 degree

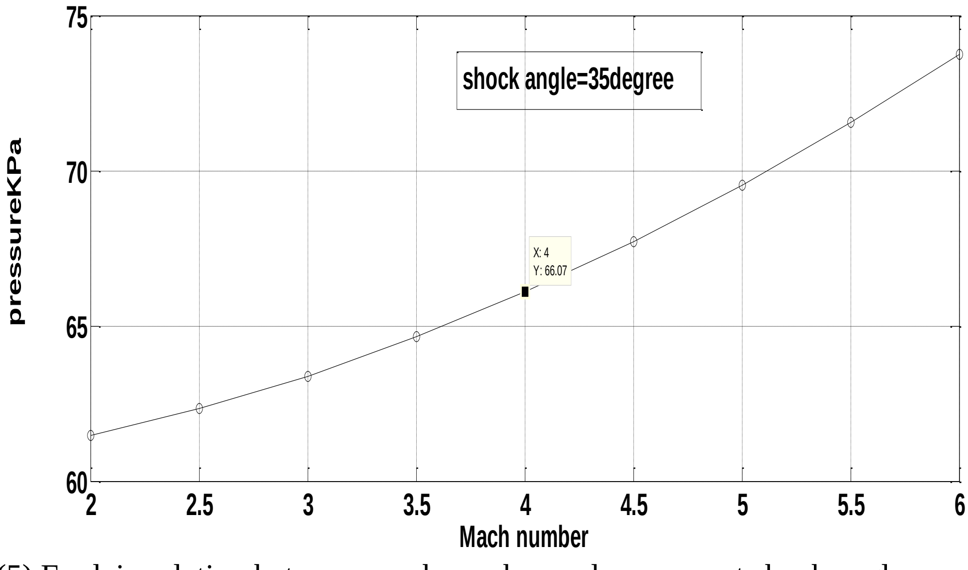


Fig (5) Explain relation between mach number and pressure at shock angle equal to 35 degree

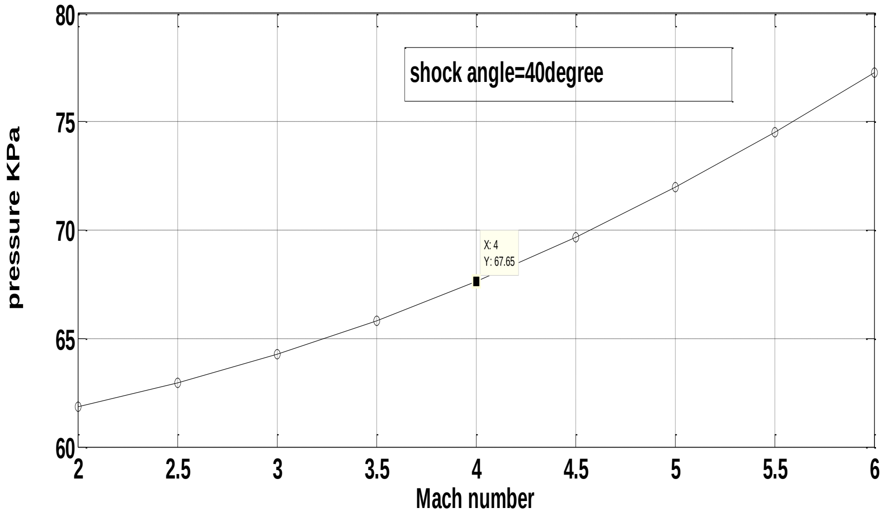


Fig (6) Explain relation between mach number and pressure at shock angle equal to 40 degree

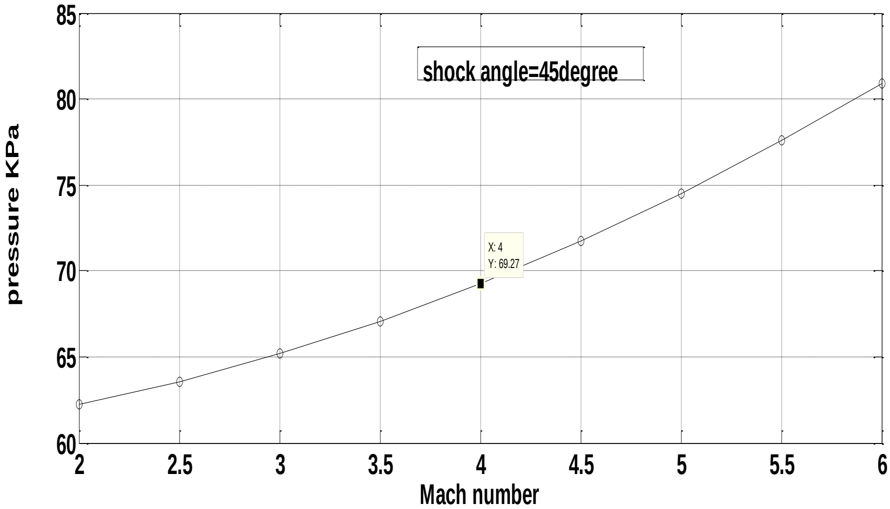


Fig (7) Explain relation between mach number and pressure at shock angle equal to 45 degree

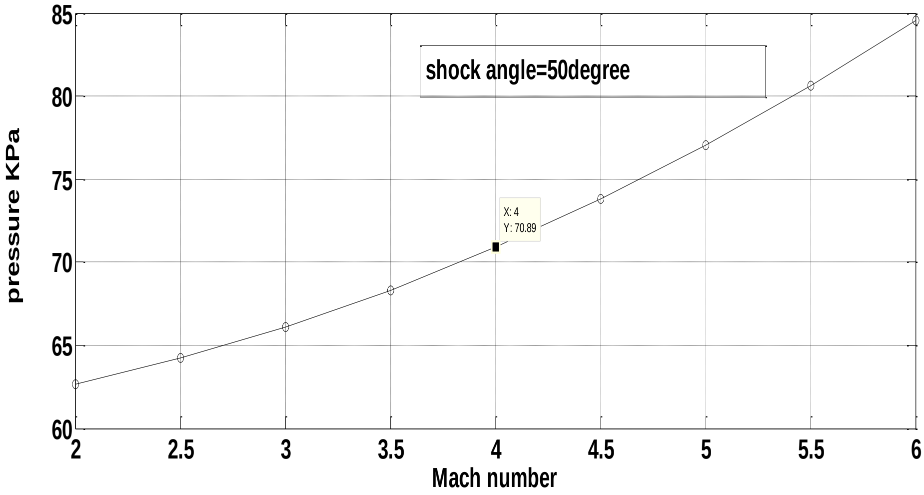


Fig (8) Explain relation between mach number and pressure at shock angle equal to 50 degree

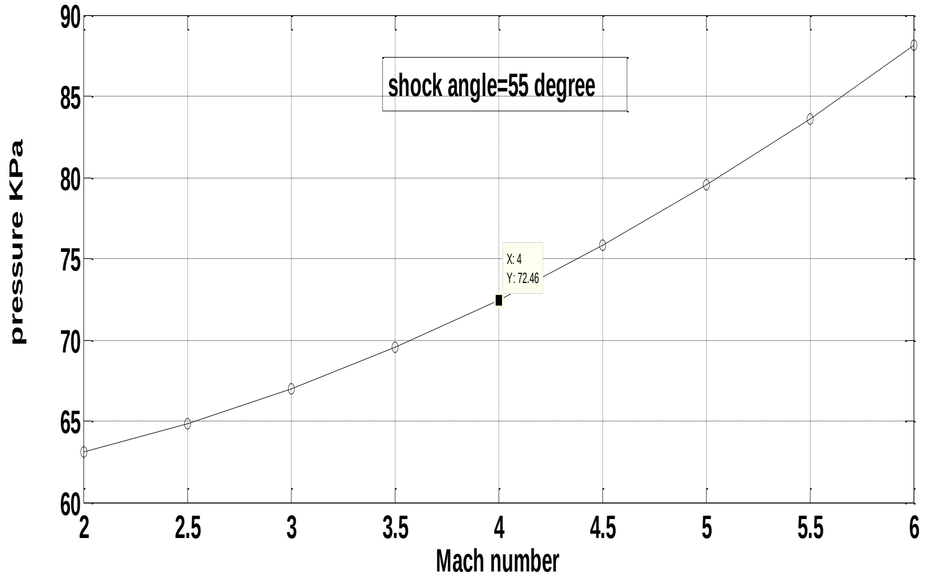


Fig (9) Explain relation between mach number and pressure at shock angle equal to 55 degree

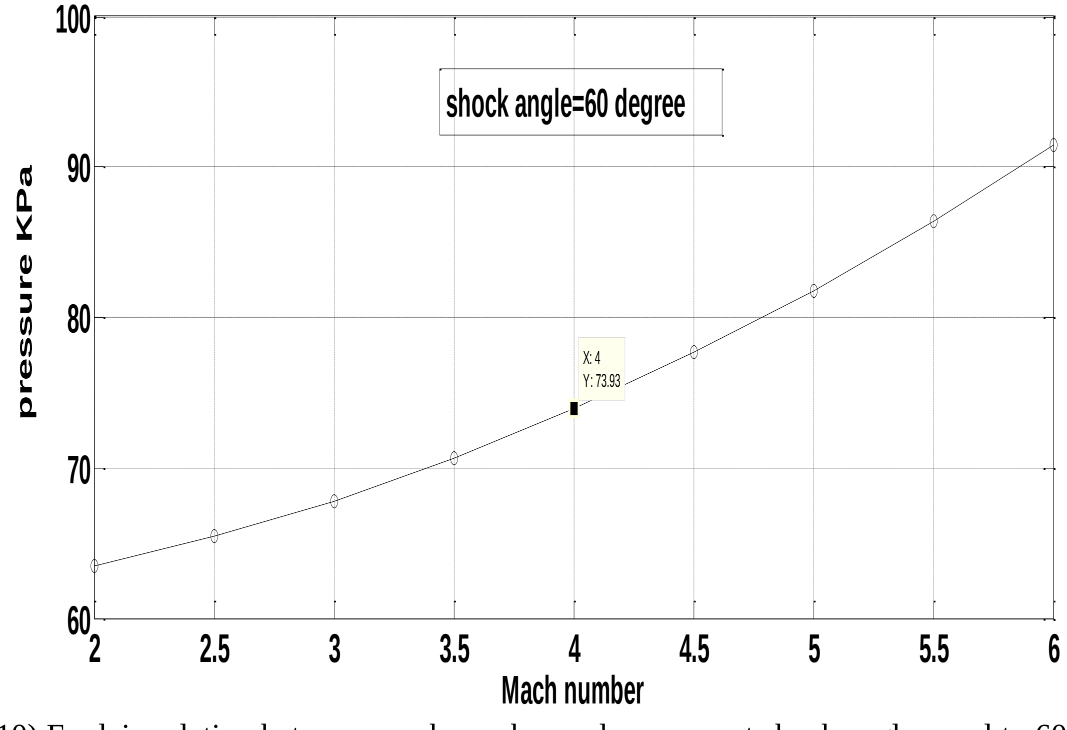


Fig (10) Explain relation between mach number and pressure at shock angle equal to 60 degree

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حساب تأثير الضغط على المقذوف على ارتفاع 4 كيلومتر عن سطح الأرض

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الخلاصة

في هذا البحث تم دراسة حركة المقذوف على أرتفاع 4كيلو متر عن سطح الأرض وكانت الدراسة في سرع مختلفة من 2ماخ الى 6 ماخ أما بالنسبة لموجة الصدمة فكانت زاويتها تتغير من 30 درجة الى 60 درجة ,وهذا يعتمد على زاوية أنحراف المقذوف المستخدم.

زاوية موجة الصدمة هي بشكل مائل وليس عمودي على السطح فلوحظ أن أقل ماخ وأقل زاوية صدمة كانتا 2ماخ و30 درجة لان هذة القيم تجعل المركبة العمودية للسرعة تصبح supersonic لذلك بدأنا بهذه القيم ,وباستخدام برنامج الــ math lab وجد أن الضغط يزداد بزيادة سرعة المقذوف وزاوية الصدمة ومن خلال معرفة الضغط المسلط على رأس المقذوف ممكن أن نعرف نوع المادة الملائمة لطيرانها وارتفاع المقذوف عن سطح البحر وسرعة المقذوف زاوية انحرافة