แบบแสดงผลการพิจารณา

การขอรับทุนสนับสนุนการวิจัย

๑. ชื่องานวิจัยภาษาอังกฤษ : "Impact Absorption Measurement of a gel sheet using an optical interferometer"

ชื่องานวิจัยภาษาไทย : "การวัดการดูดซับแรงกระแทกของเจลชีทด้วยการใช้แสงแบบอินเตอร์เฟโรมิเตอร์"

๒. ผู้วิจัย : ผศ. สง่า สงค์เมือง, คณะวิทยาศาสตร์และเทคโนโลยี สาขาวิทยาการคอมพิวเตอร์

๓. ผลการพิจารณา

☑ ๓.๑ อนุมัติ

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ลงนาม ....

(ดร.เสนีย์ สุวรรณดี)

รองอธิการบดี ฝ่ายวางแผนและพัฒนา

ประธานคณะกรรมการพิจารณาทุนสนับสนุนการวิจัย

วันที่ 20 / กค / 58

งบประมาณ

การขอรับทุนสนับสนุนการวิจัย

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๓. งบประมาณ

๓.๑ หมวดค่าตอบแทน

๓.๑.๑ ค่าตอบแทนนักวิจัย เป็นเงิน ๕๐,๐๐๐.๐๐ บาท

๓.๑.๒ ค่าตอบแทนผู้ช่วยนักวิจัย เป็นเงิน ๒๐,๐๐๐.๐๐ บาท

๓.๒ หมวดค่าใช้สอย

๓.๒.๑ ค่าเดินทางไป-กลับประเทศไทย-ญี่ปุ่น เป็นเงิน ๓๕,๐๐๐.๐๐ บาท

๓.๒.๒ ค่าใช้จ่ายต่างๆ ค่าเดินทางในประเทศญี่ปุ่น ค่าอาหาร และที่พักอาศัย จำนวน ๓๘ วัน เป็นเงิน ๑๐๒,๐๐๐.๐๐ บาท

๓.๒.๓ ค่าจัดพิมพ์โปสเตอร์สำหรับนำเสนอผลงานวิจัย ในงานประชุมวิชาการ International Conference on Industrial Application Engineering ๒๐๑๖ (ICIAE ๒๐๑๖), Beppu, Japan เป็นเงิน ๓,๘๐๐.๐๐ บาท

๓.๓ หมวดค่าใช้จ่ายในการนำเสนอผลงานและการเผยแพร่ผลงาน

๓.๓.๑ ค่าลงทะเบียนการเข้าร่วมงานประชุมวิชาการ ICIAE ๒๐๑๖ เป็นเงิน ๑๒,๐๓๕.๐๐ บาท

๓.๔ หมวดค่าวัสดุอุปกรณ์

๓.๔.๑ ค่าวัสดุสำนักงาน เป็นเงิน ๕,๐๐๐.๐๐ บาท

รวมเป็นเงินทั้งสิ้น ๒๒๗,๘๓๕.๐๐ บาท

(สองแสนสองหมื่นเจ็ดพันแปดร้อยสามสิบห้าบาทถ้วน)

ลงนาม ....

(ดร.เสนีย์ สุวรรณดี)

รองอธิการบดี ฝ่ายวางแผนและพัฒนา

ประธานคณะกรรมการพิจารณาทุนสนับสนุนการวิจัย

วันที่ 20 / ก.ค. / 58

Impact absorption measurement of a gel sheet using an optical interferometer

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Abstract

In this paper, the Doppler shift of light is used to manipulate the change in optical path length using the classical interferometer. From which, the change in optical path length is related to the change in impact force, where finally the last of impact force can be related to the gel sheet absorption.

Keywords: Impact absorption, Optical interferometer, Measurement.

1. Introduction

Over the past few years the increasing focus of the structures impact loading was proposed by several researches [1-10], such as, the force is measured highly accurately as inertial force acting on a mass [11-16], using an optical interferometer [17,18]. An optical interferometer was used to accurately measure the velocity [19,20]. There have been works more accuracy technology than classical interferometer [21-23]. Because of optical fiber sensors have been widely used in structural health monitoring and damage identification [24] due to its ability of sensing the importance structural mechanical parameters such as position, strain, stress, curvature, temperature, and etc. Furthermore, there also have been proposed the impact force and impact energy absorption tests for mouthguards have used a steel ball in a drop ball [25,26] and a method for measuring the impact force of a spherical body dropping onto a water surface, which this paper refer to the method by modifying [27].

Impact is a complex event involving several phenomena. Furthermore, the nature of impact response influences the type of damage and the extent of structural degradation. Extensive researches have been carried out concerning the impact behavior of composite materials [28]. Dynamic behavior of materials is focusing on the analysis and design of energy absorbing materials and structures. The work presented that the inertia of the composite plays a very important role in absorbing energy, which can be reduced significantly due to impact damage caused. Thus, there have been several of experiments investigations concerning the energy-absorption materials [29-32], which the interesting point at the effective way is to reduce impact pressure and other unexpected damage [33-35].

Gel sheets have been widely used in various materials due to their unique and impact resistant properties such as high elasticity and viscoelasticity [36-38]. Therefore, get sheets are very important for industrial automotive that are capable of safely withstanding significant impacts, thermal gel sheets that are dissipation of heat in electronic components, medical scar gel sheets, mat industry, and various capable for reducing extreme shock, vibration environments, high damping, protection for fragile components from earthquake effects, seat cushion and etc. Thus, the accurate measurement of a tensile strain or compressive stress plays a crucial role in many research and industrial field to create a wide range of innovative products. This has led to considerable research being carried out on impact energy absorbers. The focus of this research has been on the force acting of a metal ball onto get sheet is measured using an optical interferometer. The acceleration, displacement, and interval of the sphere are calculated from the velocity of the center of gravity of a metal ball. The light source used was a He-Ne laser in which the two wavelengths [39,40]. A high-speed camera is

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used to capture the images around the impact region, which shows the changes with the impact force. However, it is difficult to determine the uncertainty in measuring varying force acting onto the material, which is the impact absorption measurement. Thus, we are investigated in a synchronization and obtained the advantage of the product and acceleration with the force is directly calculated according to its.

In this paper, we investigated the impact absorption measurement of a gel sheet using an optical interferometer, and its validity is experimentally proposed. Results have shown in the Figures 2-5.

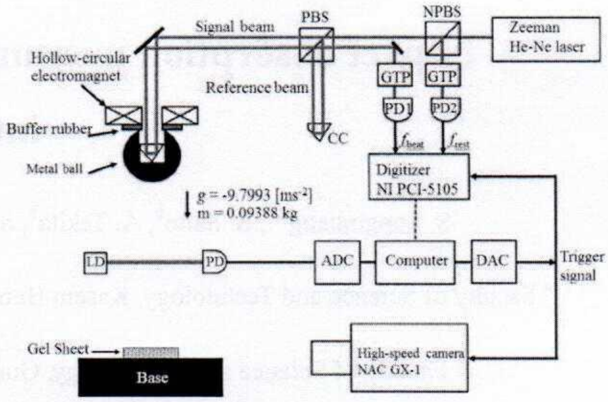


Fig. 1. A detailed schematic diagram of the experimental setup.

2. Experiment

We investigated a method for measuring the impact absorption of a metal ball by a vertical dropping (15.5 cm. drop height) onto a gel sheet, which is in 5 mm thickness and in 10x10 cm sheet size. Blue and transparent gel sheets with a sticky surface, it is elastic and very resistant to compression, covered on both sides with thin and supple polyurethane films were selected for the experiment. The total mass of the metal ball, *M*, is 0.09388 kg, and 30.2 mm in diameter was constant of all 20 sets performed, which are 10 sets for the blue get sheet and 10 sets for the other by the acceleration due to gravity. A cube corner prism, 12.7 mm in diameter, is inserted with an adhesive agent so that its optical center coincides with the center of gravity of the whole body. An optical interferometer is used to accurately measure the velocity. The force of impact and velocity against time was recorded using a high-speed camera for the interference stripe in real time with a resolution of 38400 pixels and a frame rate of 1200 fps.

Figure 1 shows a detailed schematic diagram of the experimental setup for testing the impact absorption measurement of a gel sheet using an optical interferometer. The digitizer and the high-speed camera are initiated by a trigger signal generated using DAC. This signal is activated by means of a light switch, which is a combination of a LD and PD that was switching manually. Impact occurred by releasing the metal ball from drop height 15.5 cm, which it was manually. The velocity of the center of gravity of a metal ball, in which a cube corner prism is embedded so that its optical center co-insides with the center of gravity of the ball, is accurately measured using an optical interferometer with a sampling interval of approximately 1 ms. Computer is used to record and process the data by using the LabView program. The computer recorded the data in a rate of 30 M (samples/s) and was set recorded length 5 M samples number. When initiated, the program would begin continuously scanning data into a buffer until the trigger event occurred, then save samples along with 0.073 trigger (Th) samples to a tab delimited text file and then pass the data to the next state of the program for processing. The processed data were then saved as a separate tab delimited text file and further manipulation was done using CProgram and Microsoft Excel.

The total force acting on the metal ball is equivalent to the product of its mass and acceleration; i.e., $F_{\text{mass}} = Ma$. The acceleration is calculated from the metal ball's velocity, and the velocity is calculated from the measured value of the Doppler shift frequency of the signal beam of interferometer f_{Doppler}, which can be expressed as

$$v = \lambda_{\text{air}} (f_{\text{Doppler}}) /2, \quad (1)$$

$$f_{\text{Doppler}} = -(f_{\text{beat}} - f_{\text{rest}}) \quad (2)$$

where λ_{air} is the wavelength of the signal beam, f_{beat} is the beat frequency, and f_{rest} is the frequency difference between the signal beam and the reference beam. The rest frequency f_{rest} equivalent to the beat frequency f_{beat} when the metal ball is at rest and no Doppler shift is added to the signal beam.

The total force, F_{mass}, consists of the gravitational force acting upon the metal ball, *-Mg*, and the impact force acting from the gel sheet, F_{gelsheet}, if other forces, such as the air drag and the magnetic force, are negligible. Then, the total force is

$$F_{\text{mass}} = -Mg + F_{\text{gelsheet}}, \quad (3)$$

where g is the acceleration of gravity, approximately 9.799 m/s^2 at the experimental environment.

Therefore, the impact force acting from the gel sheet can be calculated as

$$F_{\text{gelsheet}} = F_{\text{mass}} + Mg. \quad (4)$$

If other forces, such as air drag, cannot be ignored, then $F_{gelsheet}$ is assumed to include those other forces.

The velocity is accurately measured using an optical interferometer. The light source used was a Zeeman-type two wavelengths He-Ne laser had orthogonal polarization [39]. The difference between the two frequencies; i.e., the rest frequency f_{rest}, is approximately 3.0 MHz.

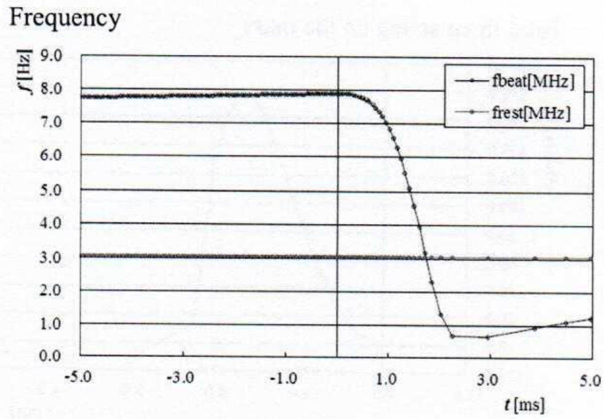
A digitizer records the output signals of PD1 and PD2 with a sample number of 5 M for each channel, a sampling rate of 30 M samples per second, and a resolution of 8 bit. The measurement duration of the digitizer is approximately 0.073 s. The frequencies f_{beat} and f_{rest} are accurately determined from the digitized waveforms of the output signals appearing at PD1 and PD2, respectively, using the recently developed Zero-Crossing Fitting method (ZFM) [40]. In our analysis, the sampling interval is defined by N = 500 periods of the signal waveform, which corresponds to 0.125 ms when f_{beat} is approximately 8 MHz.

The force of impact and velocity against time was recorded using a high-speed camera for the interference stripe in real time with a resolution of 38400 pixels and a frame rate of 1200 fps

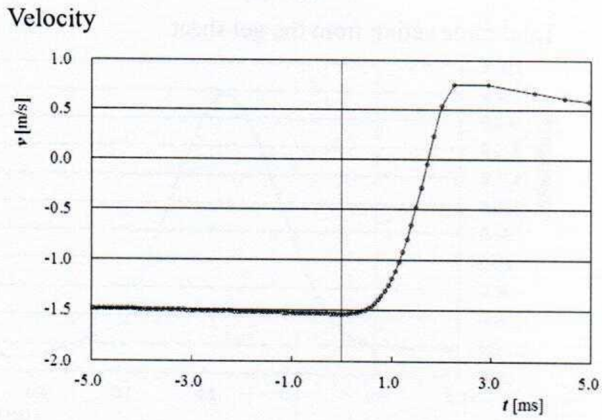
In the experiment, was constant of all 20 sets performed, which are 10 sets for the blue get sheet and 10 sets for the transparent gel sheet. In each of the test, the metal ball was fixed onto the hollow-circular electromagnet that was held and released by turned on/off manually in a vertical drop height is approximately 15.5 cm. The digitizer and the high-speed camera are initiated by a trigger signal that is generated using a DAC. This signal is activated by means of a light switch, which a combination of the LD and PD.

3. Results

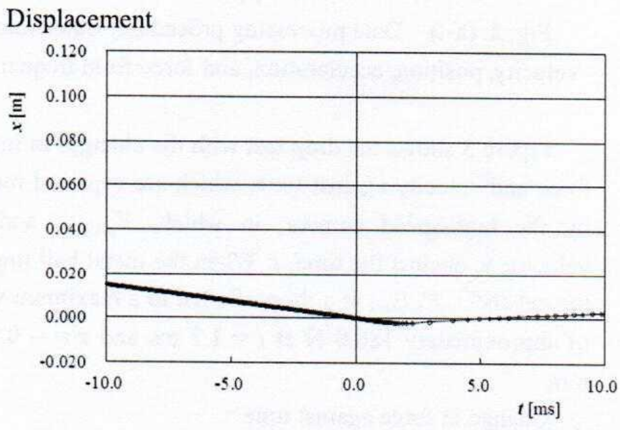
Figure 2 shows the data processing procedure, which are calculated the frequencies f_{beat} and f_{rest} that is properly measured by the beat frequency for the velocity, v; the position, x; the acceleration, a; the total force acting upon the metal ball, F_{mass}; and the impact force acting onto the metal ball from the transparent gel sheet, $F_{gelsheet}$.



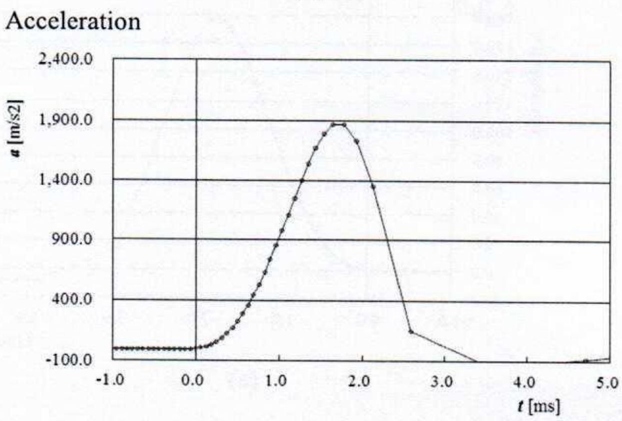
(a)



(b)

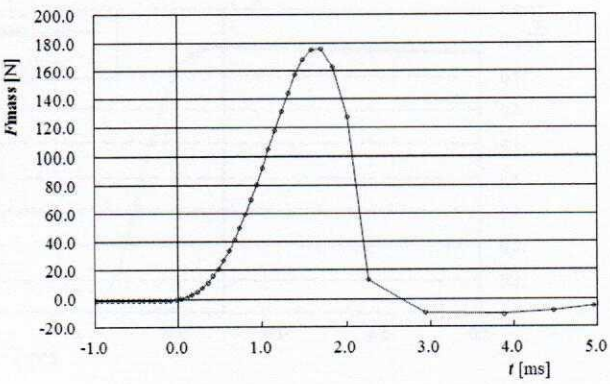


(c)



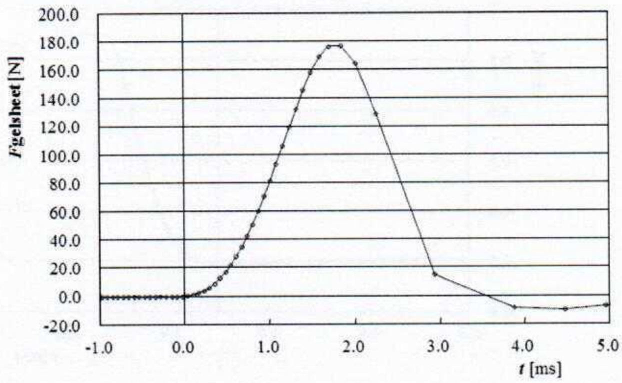
(d)

Total force acting on the mass



(e)

Total force acting from the gel sheet

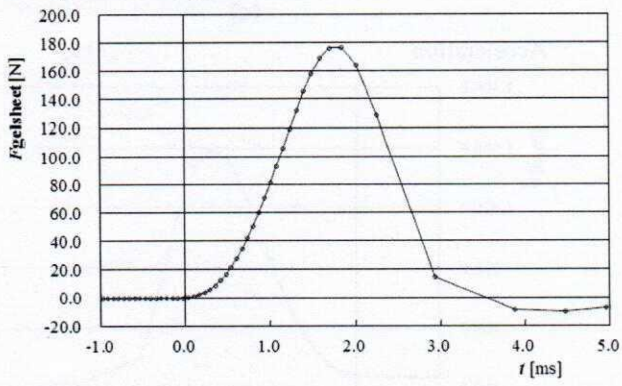


(f)

Fig. 2. (a-f) Data processing procedure: Calculation of velocity, position, acceleration, and force from frequency.

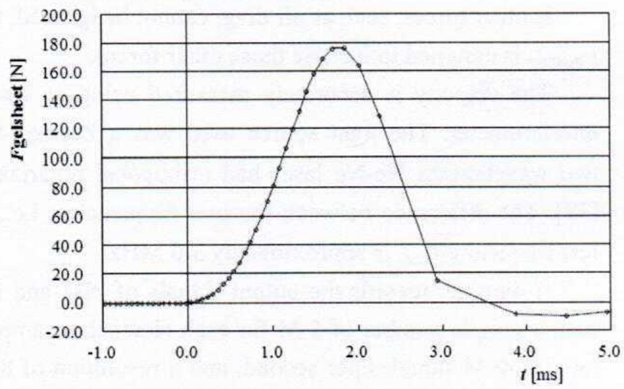
Figure 3 shows the drop test with the changes in impact force and velocity against time, which are captured images by the high-speed camera, in which, $F_{gelsheet}$, and the velocity, v, against the time, t. When the metal ball impacts the gel sheet, $F_{gelsheet}$ at a drop of a hat to a maximum value of approximately 180.0 N at t = 1.7 ms and x = – 0.0021 mm.

Change in force against time



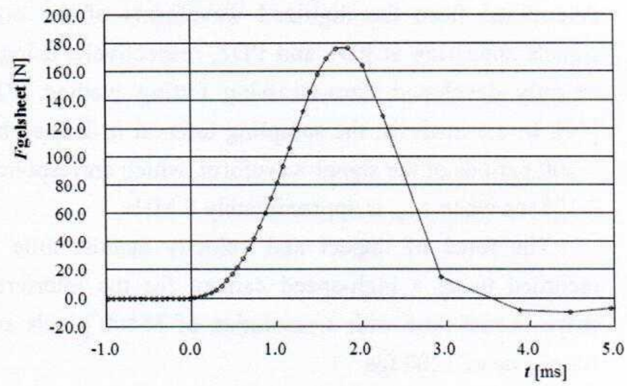
(a)

Total force acting on the mass



(b)

Total force acting from the gel sheet

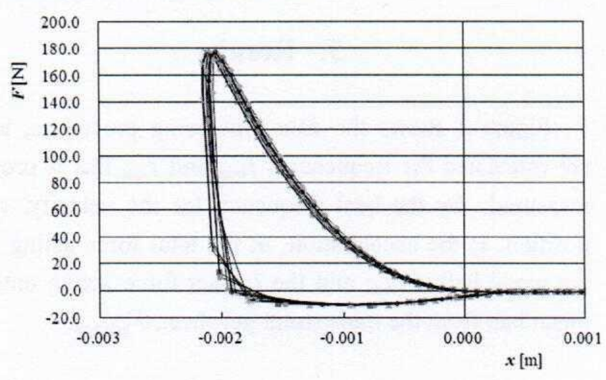


(c)

Fig. 3. (a-c) Changes in impact force and velocity against time.

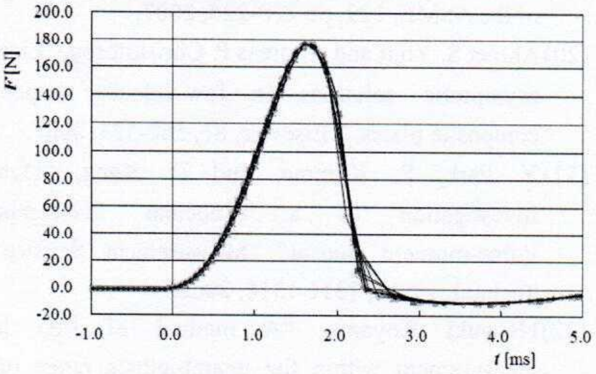
Figure 4 shows the changes in $F_{gelsheet}$ against time for all the 10 drop measurements. The results of the 10 drop measurements coincide well, indicating a high reproducibility of the measurements.

Changes in force against time



(a)

Changes in force acting from the gel sheet



(b)

Fig. 4. (a, b) Changes in force against time and changes in force acting from the gel sheet (ten drop measurements).

Changes in impact force and velocity against time

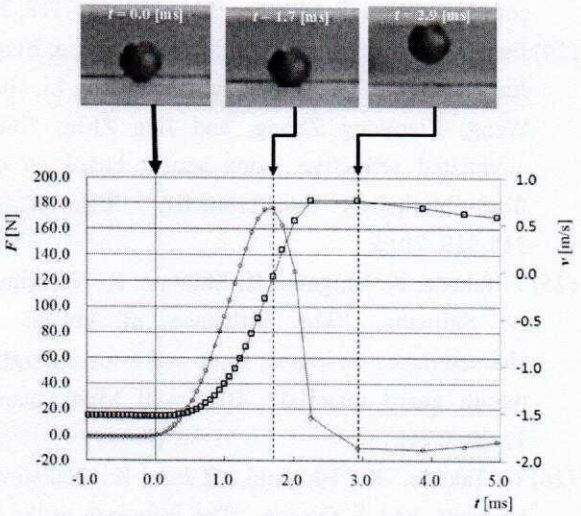


Fig. 5. Changes in impact force and velocity against time correlated with images taken by the high-speed camera.

Figure 5 shows the changes in impact force and velocity against time correlated with images taken by the high-speed camera.

4. Discussion

The sources of uncertainty in determining the instantaneous value of $F_{gelsheet}$ against time for all the 10 drop measurements are considered as follows:

Optical alignment: The major source of uncertainty in the optical alignment was the inclination of the 1 mrad signal beam; this resulted in a relative uncertainty in the inertial force of approximately $5x10^{-7}$, which is negligible

Mass calibration: The uncertainty in the mass measurement when using the electric balance was approximately 0.01 g, which corresponds to 0.01% of the total mass of the impact force. This corresponds to 0.1 mN when the applied force impact its maximum value $F_{mas,max}$ = 1.0 N, which is negligible.

Acceleration due to gravity: The acceleration due to gravity g is estimated to be 9.799 m/s with an uncertainty of 0.01 % which is negligible.

5. Conclusions

A method for testing the impact absorption measurement of a gel sheet by releasing the metal ball from drop height with the velocity of the center of gravity of the metal ball is proposed. The measurement is accurately measured using an optical interferometer with a sampling interval of approximately 1 ms. The acceleration, displacement, and inertial force of the metal ball are calculated from the velocity. The force of impact and velocity against time was recorded using a high-speed camera for the interference stripe in real time.

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