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Development of Three Dimensional Mixer Machine for Paint Industry

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ABSTRACT: Mixing is the process which determines overall quality of product in process industries like chemical plants, food processing plants, and paint industry. The stirrer of conventional machine rotates in one direction only which creates a particular flow pattern in the fluids, hence the particles tend to stick to the walls of container owing to the centrifugal force rather than thoroughly mixing of paint, ultimately results into poor quality mixture of paints. Therefore, the present paper describes the development of the Schatz geometry linkages and the drive system of three dimensional mixer machine for mixing of paints. The design of each part of three dimensional mixer machine was confirmed to be safe using theoretical and finite element method. The machine was fabricated and the experimental results indicate that the minimum paint viscosity was close to 3 Centipoise, which is best desirable for maximum luster and maximum paint spreadability was close to 200 mm, which is best desirable for minimum quantity of paint requirement.

KEYWORDS: Three dimensional mixer machine, Schatz geometry linkage, Stress, Viscosity, Spreadability.

I. INTRODUCTION

Mixing of powders is a common operation in process industry. Agitation and segregation of powders are the main issues in powder missing. The conventional mixer machines [1] involves rotation of stirrer in one or two direction only which creates a particular flow pattern in the paint and particles tend to stick to the walls of container owing to the centrifugal force rather than thoroughly mixing, ultimately results into poor quality of paint. The Schatz geometry mechanism for mixing is used for a homogeneous mixing of powdery substances with differing specific weights and particle sizes due to use of rotation, translation and inversion according to the Schatz geometric theory. Therefore, the present paper describes the development of the 3 dimensional Schatz geometry linkages and the drive system of 3-D motion mixer machine for mixing of paint.

II. LITERATURE REVIEW

S. N. Waghmare et al. [1] proposed developed a chemical mixer to reduce human efforts in small scale and institutional organizations. D. P. Patil et al. [2] designed and developed a special purpose dynamic mixer for a paint manufacturing industry. For agitation process a reversible mixtures was used, which results in effective homogenization. Mr. R. Rajaput et al. [3] employed bidirectional mixer with the crank and fork mechanism, which form the turbulence in mixer and make homogeneous mixture for higher density of powder. P. S. Jadhav et al. [4], mentioned the need of producing the apparatus having the combination of rotating, tumbling and shaking movements of a material in a container which has a closed and constrained invertible kinematic link-work of which at least one link serves as receptacle for the container. T. Yukawa et al [5], have carried out work on the conventional Continuously Variable Transmission. M. Rafieea et al. [6], has carried their work on Positron Emission Particle Tracking (PEPT) has been used to study laminar flow and mixing of a high viscosity non-Newtonian fluid in a Kenics static mixer (KM) operating continuously at constant flow rate. C. C. Lee et al [7], have carried out work on different configurations of the Schatz linkage based on the analysis of a reciprocal screw and of the relationship between the reciprocal screw and its stem-screw system. I. Bauman et al. [8], conclude that static mixers could be used for mixing of powder experimentally and mathematically, but their shape, number of mixing elements and the mixer length should be adapted for each mixture separately. H. M. Xia et al. [9] studied the influence of the Reynolds number on chaotic mixing with three mixer models. It

is found that at low Re ($Re < 1$), the flow could become reversible in the mixer, which raises the difficulty to generate chaotic advection. D.I. Cruse et al. [10], developed an apparatus having combination of rotating, tumbling and shaker movement consisting of closed invertible kinematic link and motive power for driving the link work is provided by imparting thrusting power, rather than rotating power.

III. DEVELOPMENT OF THREE DIMENSIONAL MOTION MIXTURE

Based on the summarized data from literatures and small scale industries, layout of three dimensional motion mixture machine for mixing of paint for three liter capacity was developed as shown in Figure 1. The geometrical parameters of each part were finalized and theoretical design [11-14] was performed and the results are given in Table 1. Thereafter, the FEA [15] of three dimensional Schatz geometry linkages, drive system parts was performed and is shown in Figure 2 to Figure 19. The maximum Von-mises stress, maximum deformation obtained from FEA is given in Table 1.

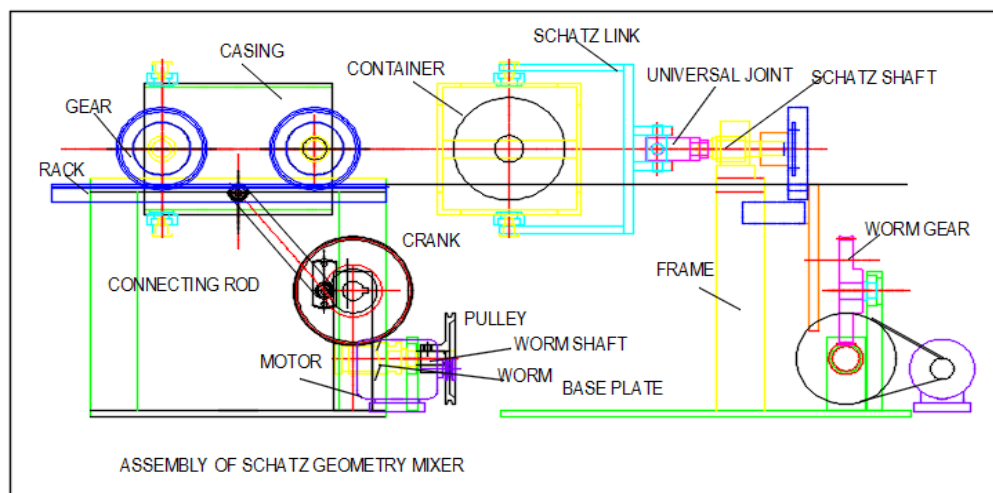


Fig. 1 Layout of three dimensional motion mixture machine

FINITE ELEMENT ANALYSIS WORM SHAFT

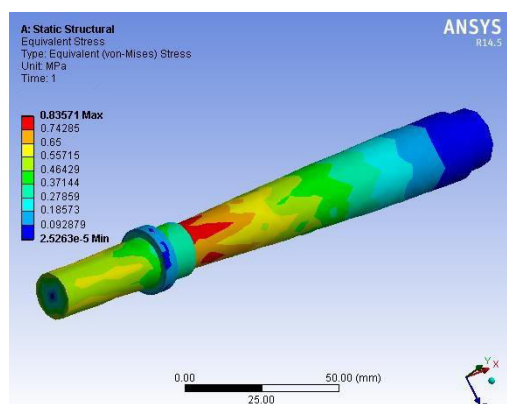


Fig. 2 Von-mises stresses

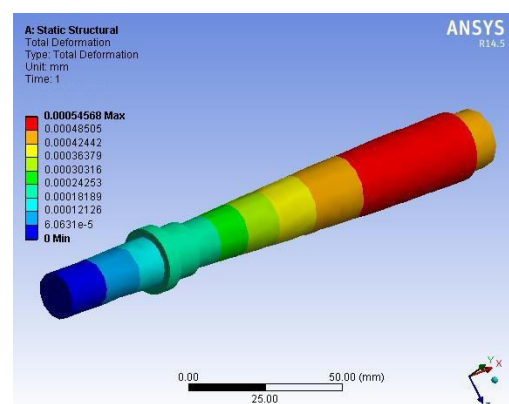


Fig. 3 Maximum deformation

WORM

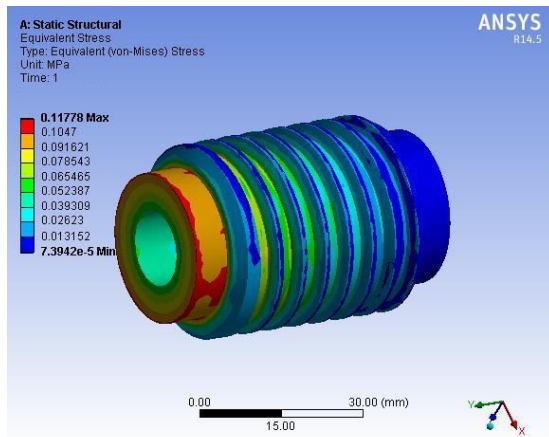


Fig. 4 Von-misses stresses

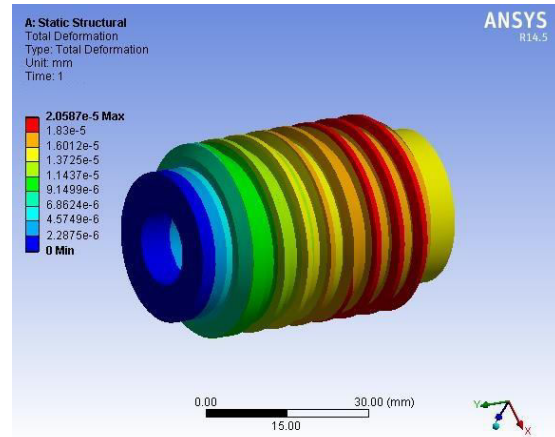


Fig. 5 Maximum deformation

WORM GEAR

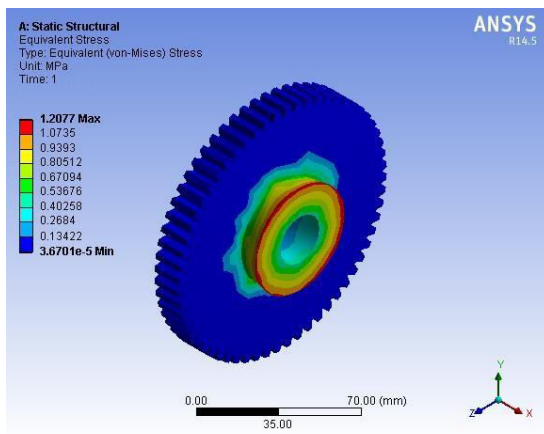


Fig. 6 Von-misses stresses

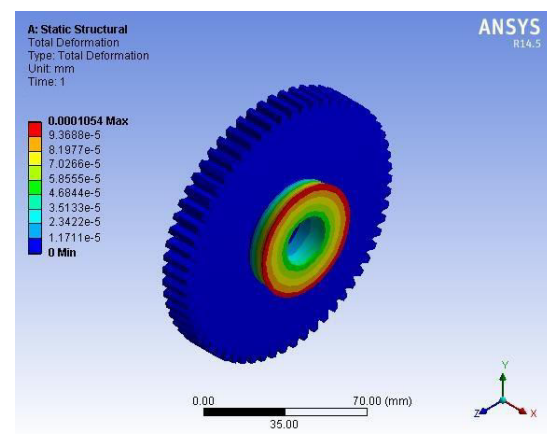


Fig. 7 Maximum deformation

WORM WHEEL SHAFT

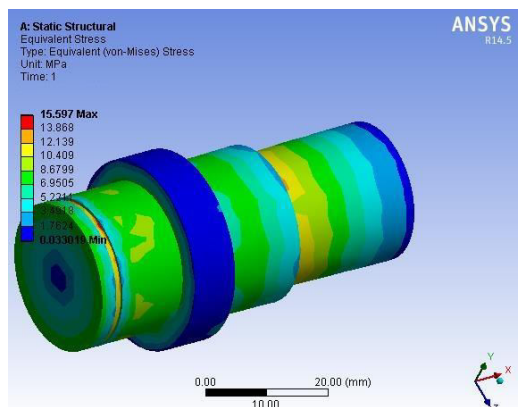


Fig. 8 Von-misses stresses

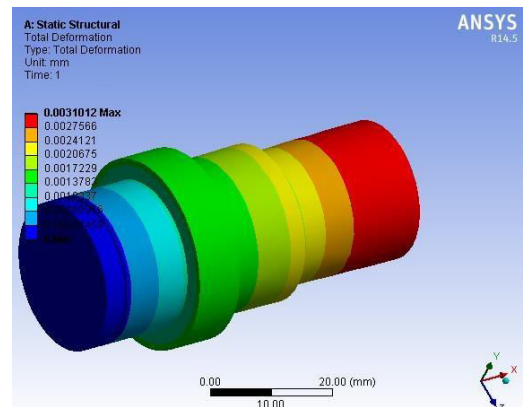


Fig. 9 Maximum deformation

CRANK

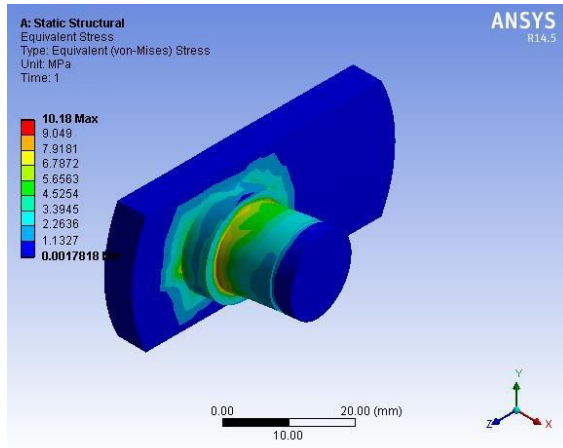


Fig. 10 Von-misses stresses

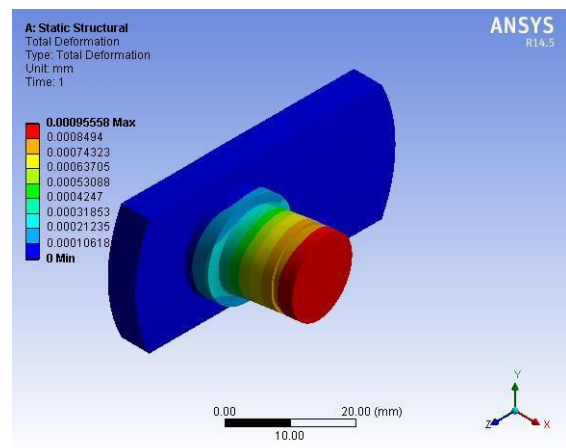


Fig. 11 Maximum deformation

CONNECTING ROD

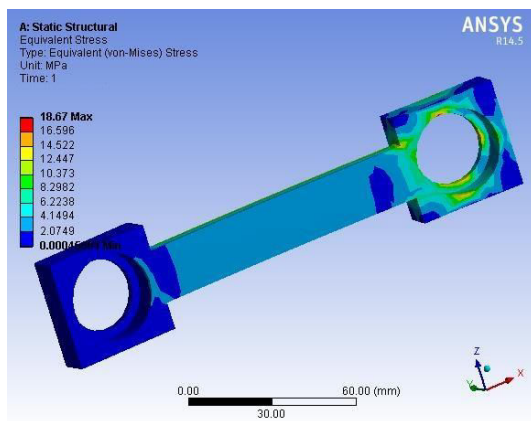


Fig. 12 Von-misses stresses

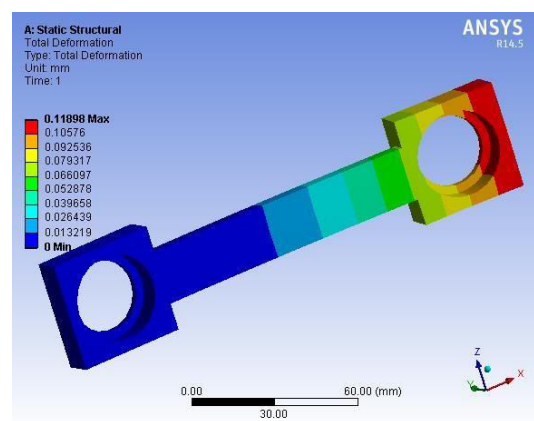


Fig. 13 Maximum deformation

SCHATZ GEOMETRY SHAFT

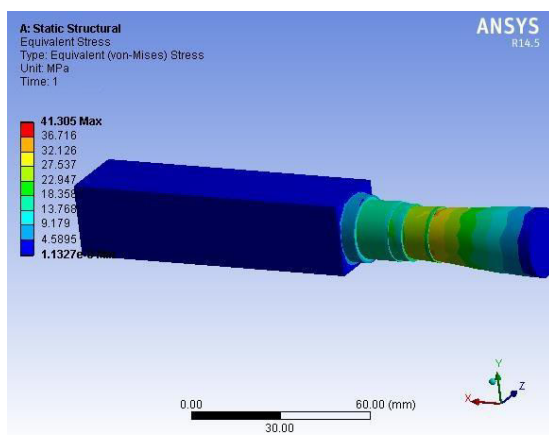


Fig. 14 Von-misses stresses

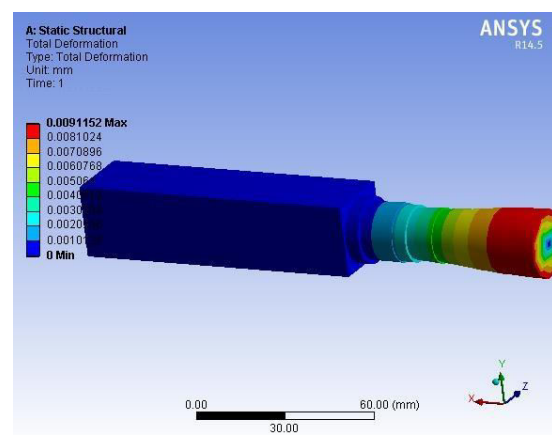


Fig. 15 Maximum deformation

SCHATZ GEOMETRY BRACKET

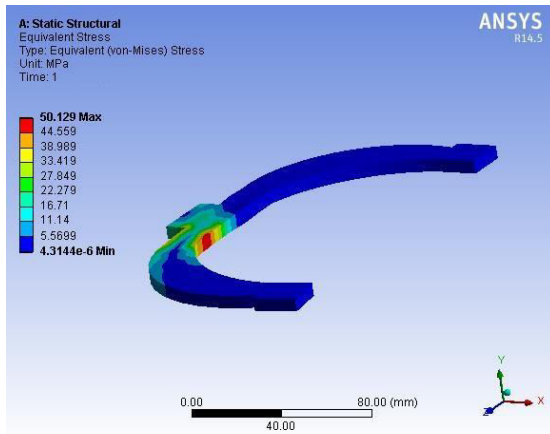


Fig. 16 Von-misses stresses

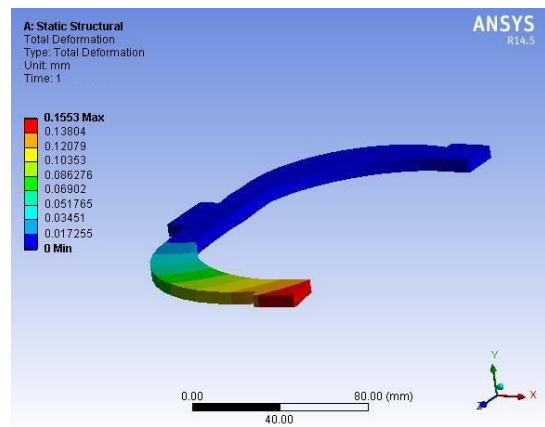


Fig. 17 Maximum deformation

CONTAINER CASING

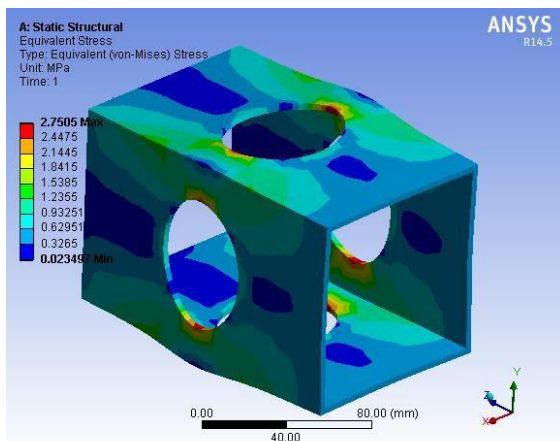


Fig. 18 Von-misses stresses

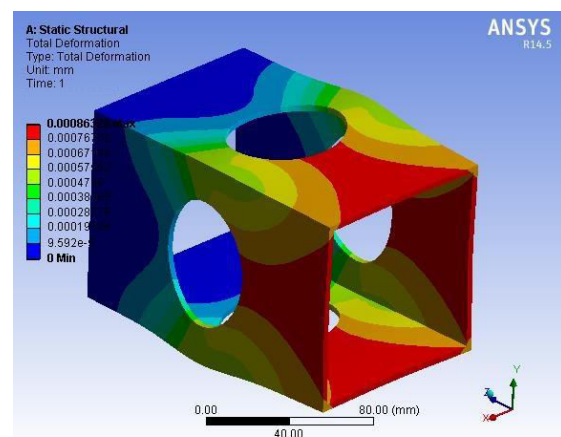


Fig. 19 Maximum deformation

Table 1 Theoretical method and FEA results

Part Name	Maximum Theoretical Stress (MPa)	Maximum Von-misses stress (MPa)	Maximum Deformation mm	Result
Worm Shaft	0.742	0.8357	0.00054	Safe
Worm	0.23	0.1178	0.0000205	Safe
Worm Gear	0.639	1.027	0.0001054	Safe
Worm GearShaft	7.23	15.597	0.00312	Safe
Crank	3.41	10.81	0.000095	Safe
Connecting Rod	5.03	18.67	0.118	Safe
Schatz Shaft	18.8	41.3	0.009	Safe
Schatz Bracket	6.71	50.129	0.1553	Safe
Casing	0.75	2.75	0.0086	Safe

Maximum stress by theoretical method and Von-mises stress by FEM are well below the allowable limit [13]; hence the design of each part is safe. FEA of all parts shows negligible deformation under the action of system of forces.

IV. EXPERIMENTAL TESTING AND RESULTS

The three dimension almotion mixture machine was fabricated as shown in Figure 20 and the performance of mixer machine with regard to viscosity, spread ability [16] was determined. The three liters of Asian-paint was poured in the containers of conventional mixer and three dimensional motion mixture machine and mixers were run for same time period. During process of mixing, viscosity of paint was measured by the use of redwood viscometer for every 3 minutes span. At the same time, spreadability was measured in mm by using glass & 0.5 mm wiper plate with 2 ml. drop of paint on glass. The observed results of viscosity & spread ability are shown in Figure 21&22.

Figure 21 indicates variation of Viscosity of paint (X axis) vsTime. Viscosity of paint was reduced at fast rate with three dimensional motion mixture machineas compared to the conventional mixer. Lower paint viscosity is desirable characteristic. It was observed that the three dimensional motion mixture machineshows lower viscosity as compared to conventional mixer. Minimum paint viscosity obtained by the three dimensional motion mixture machine was close to 3 Centipoise, which is best desirable quality for maximum luster and minimum paint requirement. Figure 22 shows that the spreadability of paint was increased at fast rate with three dimensional motion mixture machineas compared to the conventional mixer. Maximum paint spreadability obtained by the three dimensional motion mixture machine was close to 200 mm which is best desirable for minimum quantity of paint requirement.



Fig. 20 Three dimensional motion mixture machine

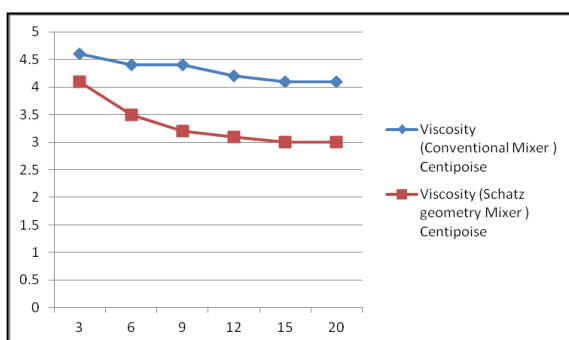


Fig. 21 Viscosity of paint Vs Time

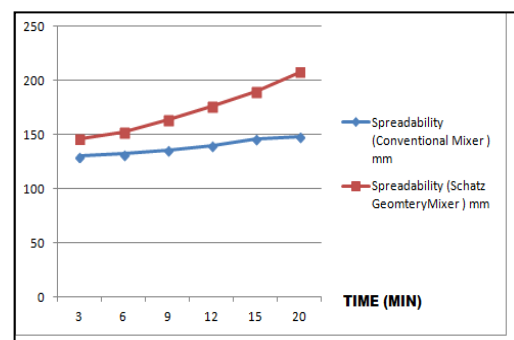


Fig. 22 Spread ability of paint Vs Time

V. CONCLUSION

Maximum stress by theoretical method and by FEM was well below the allowable limit; hence the design of each part was safe. FEA of all parts showed negligible deformation under the action of system of forces. Therefore, design of three dimensional motion mixture machine for paint application is safe. Minimum paint viscosity obtained by the three dimensional motion mixture machine was close to 3 Centipoise, which is best desirable for maximum luster and

maximum paint spreadability obtained was close to 200 mm, which is best desirable for minimum quantity of paint requirement. Therefore, the developed three dimensional motion mixture machine produces better lustered paint with reduced mixing time.

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