Safety Design and Numerical Simulation of Twin Screw Extruder for Energetic Materials

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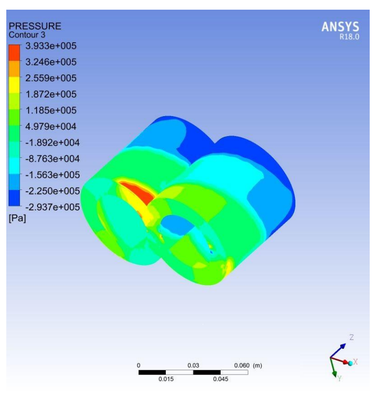
Introduction

With the requirements on weapons systems of wars increasing, new formulations of energetic material are appearing all the time. Traditional processing technologies do not unable to meet the requirements of multi-species, high-quality production.

The twin screw extruder can realize continues and flexible preparation of energetic materials. At present, there are more studies on screw structures, but less research on the safety design of barrel structures. This paper focuses on the effect of explosion venting structure of the Φ 50 twin screw extruder on the pressure distribution law and barrel deformation, and provides theoretical support for the safety design of twin screw extruder for energetic materials.

Analysis of flow field in the barrel

If the energetic material is greatly stimulated in the manufacture process, there is a high probability of explosion. So, in all the flow field parameters, the pressure and shear rate in the mixture runner have greatly effect on the safety performance.



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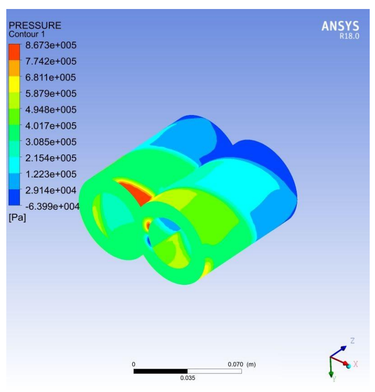

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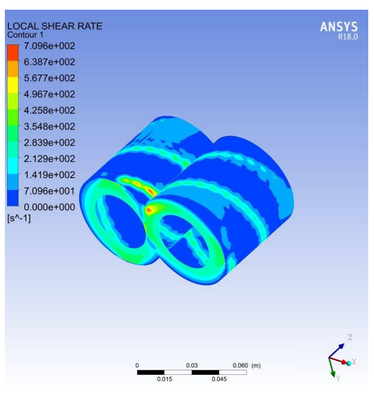
It can be seen that compared to the 50/50 specification threaded element, the 75/75 specification threaded element can produce more pressure in the runner, and maximum pressure on the material increases by 2.21 times. Comparing the pressure contours in the figures, it is observed that the maximum pressure on the material is found on the top of the screw flight and in the intermeshing region.

As can be seen from Figure , compared with the 50/50 specification threaded element, the 75/75 specification threaded element produces a slightly higher shear rate. Similar to the pressure contour, the high shear rate areas appear on the top of the screw flight and in the intermeshing region.



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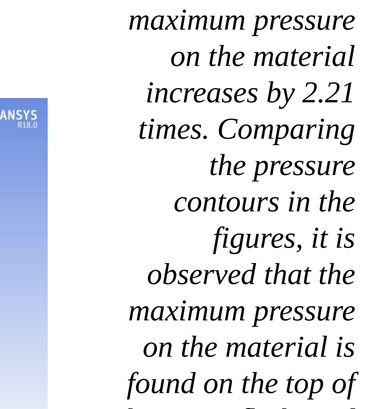

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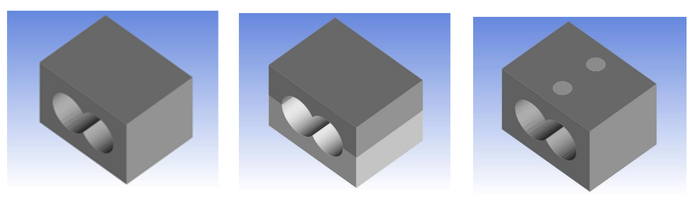
Safety analysis of barrel structure

The ordinary barrel is shown as barrel (a). Two explosion venting structures are shown as barrel (b) and barrel (c).

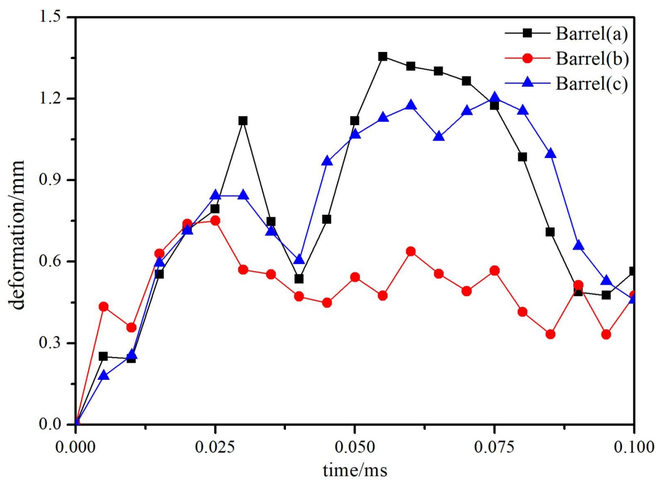


barrel(a) barrel(b) barrel(c)

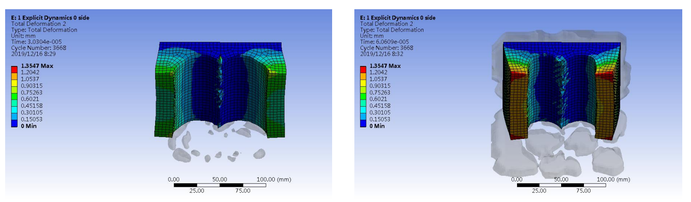
According to the simulation results, the top of the screw flight and the intermeshing region are easy to incur explosive accidents and the detonation point locations.

Deformation of barrel fixed part

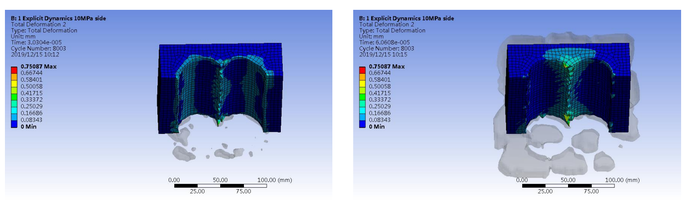
- The detonation points on the top of the screw flight



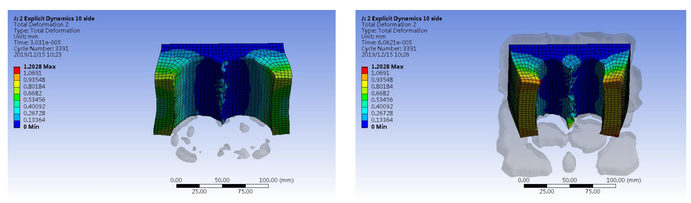
When explosive happens, the deformation of the barrel (a) increases rapidly, and the first peak occurs around 0.03 ms. Under the action of secondary impact, the deformation reaches the maximum value at about 0.06 ms. The fixed part of barrel (b) has the largest deformation around 0.025 ms, and then the deformation decreases gradually. On curve of barrel (c), the first peak appears around 0.025 ms, which is relatively flat. There are two consecutive large deformations around 0.65 ms and 0.75 ms, which indicate that the impact of the explosion has not been effectively relieved.



barrel (a)



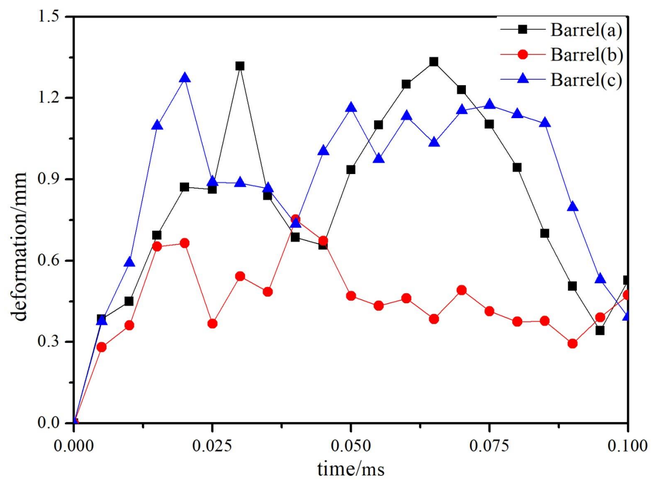
barrel (b)



barrel (c)

Compared the figures, we can see that the fixed part of the barrel (a) appears significant deformation. Although the maximum deformation of the fixed part of the barrel (c) is smaller than that of the barrel (a), compared with the barrel (b), the deformation is still very obvious.

- The detonation points in the intermeshing region



The deformation of the barrel (a) increases rapidly after explosive. The first peak occurs at about 0.03 ms. Under the action of secondary impact, the deformation reaches a large value at about 0.065 ms. The barrel structure of the intermeshing region is relatively thin, so the initial impact of the explosion in this area has a greater effect on the barrel. The fixed part of barrel (c) has the largest deformation at about 0.02 ms. And then the deformation reduces gradually but getting larger from 0.05 ms to 0.085 ms. The maximum deformation of the fixed part of barrel (b) appears at about 0.03ms. The deformation curve is flat, indicating that the impact of the explosion has been effectively relieved.

Based on the above analysis, we can see that compared with the ordinary barrel, when the explosive happens in the horizontal split barrel, the deformation of fixed part significantly reduces, and the changes in deformation over time is fewer. When the explosive happens in the barrel with two pressure relief holes, the deformation is slightly reduced, and there is a significant secondary impact effect, which leads to the a large deformation.

Conclusions

1 In the process of energetic material production by twin screw extruder, the maximum pressure and shear rate appear on the top of the screw flight and in the intermeshing region where are easy to incur explosive accidents and the detonation point locations.

2 Compared with the ordinary barrel structure, the pressure in the horizontal split barrel is obviously reduced. Since the barrel is opened by shock wave, the secondary pressure peak disappears, and the deformation of the fixed part of the barrel decreases significantly.

3 Compared with the ordinary barrel structure, the reduction of pressure in the barrel with two pressure relief holes is not obvious. Under the effect of the two shock waves, the barrel has a large deformation.

4 Using the twin screw extruder with the horizontal split barrel to produce energetic materials can reduce the damage to the barrel in an accident and improve the safety performance.

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